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ABSTRACTS OF THE GEOLOGICAL SOCIETY OF AMERICA

DECEMBER MEETING AT BOSTON

STRATIGRAPHY AND STRUCTURE OF THE FINLAY MOUNTAINS, TEXAS

BY CLAUDE C. ALBRITTON, JR., AND WILLIAM O. HAM *

The Finlay Mountains of southern Hudspeth County, Texas, lie approximately on the boundary between the Sierra Madre and the Basin-and-Range structural provinces. The mountains are of Permian and Lower Cretaceous sedimentary rocks cut by dikes and parted by sills and laccoliths of late Cretaceous or Tertiary age. Valleys and small intramontane basins contain Cenozoic alluvial deposits similar to those in the Hueco Basin to the south.

Permian rocks aggregating approximately 1700 feet in thickness consist of flaggy siltstone, shale, cherty limestone, and conglomerate. Marine fossils, including some typical Leonard species, are found at many horizons from the bottom to the top of the section.

Resting with angular unconformity on the Permian is the oldest Cretaceous formation, the Campagrande, 630 feet thick at the type locality, and consisting mostly of siltstone and impure limestone. Conformably above the Campagrande is the Cox formation, 660 feet thick near the western end of the mountains, where it is mostly sandstone, quartzite, and siltstone. Succeeding the Cox conformably is the Finlay formation—200 feet or less of limestone and marl.

Structurally the mountains are dominated by two domes with their centers aligned northwest. Centrifugal dips around the domes generally do not exceed 20° and are steeper on the south than on the north. Lifting of the sedimentary roof above the smaller southeastern dome was partly accomplished by vertical movements along arcuate faults. The domes probably overlie laccoliths, like those of Sierra Blanca peaks 5 miles to the southeast.

STRUCTURES IN THE ROCKY MOUNTAINS OF WESTERN ALBERTA

BY J. A. ALLAN

A section across the Rocky Mountains in Alberta from the Continental Divide at Howse Pass to the major overthrust at the eastern face of the mountains has been studied. This 50-mile section was examined along the valley of the North Saskatchewan River which cuts obliquely across the structure. Only a small part of this section has been previously examined.

The rocks range in age from lower Cambrian to Mesozoic and occur in three distinct structural units separated by major structural breaks. Faulting largely of thrust type with low and high angles appears to have extended over a long period. Earlier fault planes have been disturbed by later movements. Faults are more numerous and more important than folds formed in an early stage of compression. Low-angle overthrusting is later than high-angle thrusting. Normal faults indicating tension are younger than thrust faults. The stratigraphic column involves about 3 miles of strata. Evidence has been obtained on thicker series than previously recognized, and at least one new formation has been observed.

* Introduced by Ellis W. Shuler.

GEOLOGY OF THE GULF OF CALIFORNIA

BY CHARLES A. ANDERSON

Observations made on the recent E. W. Scripps cruise to the Gulf of California add information concerning the later geologic history of the gulf and of Lower California. The islands along the western margin of the gulf consist of tilted volcanic rocks of middle Tertiary age overlain unconformably by the Pliocene sediments. The volcanic rocks are similar to the Comondu formation of Lower California that dips moderately to the west. On the islands, the structure of the steeply dipping volcanics suggests that they were separated from the peninsula by faulting. The Pliocene sediments—gravels, sands, and limestones—were deposited in small embayments with the older rocks rising topographically above, identical to the environment of recent sediments of similar lithology. This suggests that the Gulf of California and the peninsula of Lower California were blocked out essentially in their present form by early Pliocene. If the Imperial formation (upper Miocene) in southeastern California with its Caribbean affinities was deposited in the seaway that initiated the present gulf, considerable faulting has modified that seaway producing the modern gulf. The lower and middle Pliocene rocks have been folded and faulted, while the upper Pliocene sediments have only been upwarped or faulted. Numerous Pleistocene terraces occur on most of the islands, and some of these have been faulted. The extension of Mesozoic granite from Lower California through some of the islands to Sonora indicates that the islands are blocks that did not subside during gulf formation. Only two islands represent volcanic cones. (Geological Society project.)

PHYSIOGRAPHIC EVOLUTION OF THE NORTHERN DIVISION OF THE ROCKY MOUNTAINS

BY WALLACE W. ATWOOD AND WALLACE W. ATWOOD, JR.

In carrying northward studies in the Rocky Mountain province, first reported in the Bulletin in 1938, the writers continue to find extensive areas of the subsummit erosion surface which they have called the Rocky Mountain peneplain. Abundant evidence is present of mid-Tertiary filling which occupied a very considerable area in the Rocky Mountain region in Pliocene times, when an extensive "cycle-end surface" characterized most if not all of this physiographic province. Evidence of marked orographic movements in late Tertiary time, subsequent to the development of the Rocky Mountain peneplain, is present in the area. Vast quantities of the mid-Tertiary basin filling have been removed, uncovering some mountains and making others conspicuous topographic features.

In Montana and Idaho Cordilleran ice has modified the late Tertiary erosion surface of the mountain area and produced many of the topographic details in the valley bottoms. In northern Montana and in the Canadian Rockies, as far north as Jasper, uplift of the mountains has been on a gigantic scale. Vigorous stream and ice erosion is still in progress; the topography is in a stage of extreme youth. The Canadian portion of the Rocky Mountain front range appears to be a land without a Tertiary peneplain.

LATE PLEISTOCENE COAST RANGE OROGENESIS IN SOUTHERN CALIFORNIA

BY THOMAS L. BAILEY

The thickest known columnar section of Pleistocene in the world, about 5400 feet of strata, is well exposed near Ventura in southern California. Even here Pleistocene

sedimentation is far from complete because this sedimentary succession is separated into two parts by a profound angular unconformity which must have been accompanied by extensive uplift and erosion. The two divisions of the Pleistocene column are (1) an underlying 5100 feet of Lower Pleistocene terrigenous shales, mudstones, sandstones, and conglomerates, mainly of marine origin, which dip 35° to 75° south, and (2) an overlying 300 feet or less of Upper Pleistocene fluviatile gravels and silty sands which dip only 8° to 15° south. Land vertebrates, including *Equus* cf. *occidentalis* in both divisions and a large marine invertebrate fauna in the lower steeply dipping group, demonstrate that both these groups of strata are of Pleistocene age.

Paleontologic, stratigraphic, and structural evidence point clearly to the conclusion that one of the principal intervals of orogenesis in the transverse (east-west) Coast Ranges of southern California occurred during the Pleistocene, not at the beginning as has been common belief in the past. This evidence suggests that two of our widely held geological concepts need to be modified as follows:

(1) Extensive uplift and erosion may take place in a geologically short time in tectonically active areas such as California.

(2) The Pleistocene may involve a longer and even more varied lapse of time than is generally supposed.

AFRICAN RIFT VALLEYS AND AMERICAN TRIASSIC TROUGHS

BY GEORGE W. BAIN

Topography of Africa's western rift conforms to structure. Its borders display all features recognized along Triassic basins of the Appalachians. Rift geology clarifies many features of eastern Triassic troughs.

The western wall fault zone is more continuous than the eastern one. The Ituri lowland and Semliki valley merge opposite towering Ruwenzori; where Ruwenzori shrinks southward, the Kabasha escarpment rises opposite and divides them. Everywhere an unusually high fault scarp on one side is matched by an opposing gap. Echelon breaks, striking more southwesterly than the main zone, define the rift border. Ruindi escarpment slickensides pitch 10° northward where exposed 700 feet east of the main fault at Hot Springs. The brecciated scarp has receded uniformly here and at Kabasha where road cuts expose brecciated schist, gneiss, and minor shear zones for 2 miles into the mountain. The boundary fault follows the lowland side of the brecciated zone. Scarp recession and alluviation at major streams buried the fault in detritus from its own mountain. The lowland's boundary is the receded fault scarp, not a more westerly boundary fault.

Faults shift from the east to west side for different Triassic basins. Talus and landslide deposits along the eastern margin from Amherst northward are explained satisfactorily only by making the receded scarp they mantle the Triassic boundary structure. Southwesterly trending boundaries of Triassic troughs at Amherst, Granby, and possibly near Middletown, Connecticut, represent major echelon fault zones. Similar offsets are indicated in the pattern of more southern basins.

BEARTOOTH ICE FIELD

BY ARTHUR BEVAN

The Beartooth Mountains northeast of Yellowstone National Park were severely glaciated during two, and possibly three, Pleistocene stages. A notable feature of the glaciation was a large ice field on the southwestern slope of the range. Apparently it

was similar in position, form, and distributaries to existing ice fields in the Rocky Mountains in Canada, such as the Columbia ice field in Jasper National Park. Huge distributaries spilled across the "summit plateau" divide of the range into some of the deep valleys on the northeast slope, where they formed floes out upon the adjoining Great Plains. Other distributaries pushed up valleys in the neighboring Absaroka Range to the southwest and down slope into the Yellowstone National Park area. Investigation of the extent and detailed features of this remarkable ice field has not been completed but is at intervals in progress.

RELATIONS AND AGE OF THE CATOCTIN FORMATION IN CENTRAL VIRGINIA*

BY ROBERT O. BLOOMER AND RICHARD R. BLOOMER†

Detailed studies in the Blue Ridge in the Buena Vista quadrangle near Lexington, Virginia, have shown a striking similarity in the lithology of the Catoctin and Unicoi formations. It is believed that the metabasalt at the top of the Catoctin and the basalt flow at the base of the Unicoi formation in this area are genetically related. Volcanic tuff and arkosic sandstone and conglomerate in the two formations are petrographically alike.

The Catoctin and Unicoi formations each overlie pre-Cambrian granodiorite and are locally characterized by a basal conglomerate composed of granodiorite boulders. The contact of the Unicoi and Catoctin formations is, throughout the area, marked by thrust faults. These relations lead to the conclusion that the Catoctin formation in the Buena Vista quadrangle was deposited east of its present locality.

The absence of the Catoctin formation beneath the Unicoi formation in the Buena Vista quadrangle, the lithologic similarity of the two formations, and the presence in both of extrusions of identically peculiar basaltic composition lead to the tentative conclusion that the Unicoi formation stratigraphically overlies the Catoctin formation by a continental overlap. Consequently the Catoctin is thought to be an early Cambrian formation separated from the Unicoi formation by a minor unconformity.

POSSIBLE GLACIAL STAGES HERETOFORE UNRECOGNIZED IN THE MIDDLE WEST

BY KIRK BRYAN

The essential subdivisions of the Pleistocene are climatic, and interpretation of Pleistocene stratigraphy depends on the recognition of the climatic significance of each member of a glacial sequence. Loess has not yet been given its full value as an indicator of the cold and windy climate of the time of glacial advance and until recently has been interpreted as interglacial. It is now recognized by leading students of the Pleistocene that the Tazewell loess, formerly called Peorian, is of Iowan age and represents merely a partial retreat of the Iowan ice, but with no great diminution in the severity of the climate.

If other loesses are interpreted in a similar way important changes in glacial chronology result. The Loveland loess and accompanying beds are presumably of two ages, and parts fall into both the Kansan-Illinoian and Illinoian-Iowan intervals. If these loesses are interpreted in the same way as the Iowan, they are the periglacial representatives of ice sheets that failed to reach as far south as the Wisconsin (including Iowan). These heretofore unrecognized in advances occupy the same position in the sequence as the advances in the second (pre-Riss) and third (pre-

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† Introduced by Arthur Bevan.

Wurm) interglacials advocated by several European glacial geologists. The main body of the Loveland loess and accompanying gravel and sand are representative of the corresponding American pre-Wisconsin or preferably Loveland glaciation. The detached bodies of loess, heretofore confused with the Loveland or included with the Yarmouth and accompanying gravel and sand, become the representatives of the pre-Illinoian glaciation for which no name is available.

METHOD PROPOSED TO INTRODUCE THE CONCEPT OF "LIMITS OF ERROR" INTO THE STRATIGRAPHIC TIMING OF TECTONIC MOVEMENTS

BY WALTER H. BUCHER

For a scientific appraisal of the nature of tectonic movements accurate knowledge concerning the factor "time" is essential. An absolute measure of time is required for adequate estimates of the rate at which tectonic movements proceed, while relative timing figures largely in the problem of synchroneity of tectonic movements. The latter is one of the pressing problems of tectonics. Much factual knowledge has accumulated but is out of reach of the student of tectonics because no concerted effort has been made so far to introduce precision into the records of stratigraphic timing.

In this paper steps are outlined directed to that end, as follows:

(1) Choosing a stratigraphic scale of reference that involves a minimum of inference and corresponding uncertainty, and a maximum of usefulness.

(2) Choosing the markers on this scale of reference.

(3) Evaluating the methods of correlation and creating simple terms (and corresponding notation) by which each may be referred to.

(4) Expressing verbally (and by notation) the upper and lower limits of possible and probable error in the position on this scale of a given tectonic movement.

The discussion is based on tectonic movements in the Rocky Mountains in California, and in Europe.

It is hoped that students of tectonics as well as stratigraphers and paleontologists will recognize the possibilities of some such method and will undertake its elaboration and standardization, preferably through a committee of the National Research Council.

NATIONAL RESEARCH COUNCIL AND RESEARCH PROGRAM OF THE GEOLOGICAL SOCIETY OF AMERICA

BY WALTER H. BUCHER

This paper is an analysis of the results of 20 years of work (along geological lines) of the Division of Geology and Geography of the National Research Council and its bearing on the formulation and organization of research programs in North America, especially in The Geological Society of America.

ORIGIN OF SULPHIDES IN THE NICKEL DEPOSITS OF MOUNT PROSPECT, CONNECTICUT

BY EUGENE N. CAMERON*

Nickel-bearing deposits occur at a number of places in the intrusive complex of Mount Prospect, near Litchfield, Connecticut. The ores are noritic and pyroxenitic

* Introduced by C. P. Berkey.

rocks containing varying amounts of pyrite, pyrrhotite, pentlandite, and chalcopyrite. The rocks are largely free from characteristic hydrothermal alteration products. This feature and the textural relations of sulphides to silicates in the ores have previously been taken to indicate that the sulphides are of magmatic or late magmatic origin.

A detailed study of the intrusive complex has furnished field data and new microscopic evidence which relate to the problem of sulphide origin. Mapping has shown that the principal ore-bearing rocks comprise intrusives of three different types: mafic norite, norite, and hypersthene pyroxenite, intruded in that order. The nickel deposits are concentrations of sulphides at or near the margins of these intrusives. Apart from the sulphides, the rocks consist essentially of hypersthene, clinopyroxene, plagioclase, hornblende, and biotite. Indications have been found that hornblende, at least in part, and biotite developed after solidification of the rocks. The sulphides appear to have been introduced later and to have formed chiefly by fracture filling and by replacement of the various silicates. No specific conclusions have been reached as to time of sulphide deposition for the deposits as a group, but the presence of introduced sulphides in fine-grained dikes cutting mafic norite and norite at two deposits suggests that a considerable interval elapsed between solidification of the latter rocks and development of sulphides. (Geological Society project.)

PALEOZOIC GEOGRAPHY OF SOUTH AMERICA WITH PARTICULAR REFERENCE TO THE DEVONIAN

BY KENNETH E. CASTER

As a result of the discovery and study of Middle Devonian faunas in the northern Andes of Colombia and Venezuela it has been necessary to evaluate somewhat critically the existing views on the mid-Paleozoic geography of South America. Three epochs of Devonian history are recorded in varying degree on the continent. For the Lower and Middle Devonian, at least, sufficient data are now available to indicate the main marine connections that must have existed. As a guide in the interpolation of the courses of the biotically required seaways, the present evidence for which is often at widely separated stations, a synthesis of the Paleozoic geographic elements of South America has been drawn up. The plotting of all Paleozoic occurrences on the continent for the purpose of the synthesis brings out a remarkable constancy of certain geographic features throughout the era. These have been analyzed in a very general manner as to relative negative or positive quality during the era, and old lands (borderlands), emergent shields, swells, geosynclines, troughs, epeiric seas and seaways, basins, and bights delimited. The resultant picture differs somewhat from customary generalizations as to the nature of Paleozoic South America. Because of the adherence to this generalization in drawing Devonian seaways, they appear to have been kept well within the realm of structural possibility at any rate.

ATHENS EQUIVALENTS NORTHWEST OF CLINCH MOUNTAIN IN SOUTHWEST VIRGINIA*

BY BYRON N. COOPER

The Athens formation, which constitutes a major part of the post-Beekmantown—pre-Martinsburg succession in the southeastern belts of the southern Appalachian Valley in Virginia, has been considered by some geologists to be absent in the belts northwest of Clinch Mountain. In localities southeast of Clinch Mountain, near

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Ceres and Sharon Springs, Bland County, Virginia, Athens limestones and shales contain representatives of the *Nemagraptus gracilis* graptolite fauna and, in addition, *Nidulites pyriformis*, sponges of the *"Receptaculites"* type, and species of *Oxoplecia, Schizambon, Sowerbyella, Lingula, Calliops, Niobe, Remopleurides,* and *Homotelus.* In Tazewell County, Virginia, northwest of Clinch Mountain, a 120-foot zone of cherty limestone carries apparently the same faunal assemblage but without graptolites. The beds underlying and overlying this zone appear to be the same as those below and above the Athens southeast of Clinch Mountain in Bland County. Athens equivalents in Tazewell County are believed to be a limestone facies of the typically shaly Athens of the southeastern belts.

FACIES RELATIONS OF THE MIDDLE DEVONIAN (HAMILTON GROUP) ALONG THE CATSKILL FRONT

BY G. ARTHUR COOPER

Study of Hamilton sediments in the tilted belt along the Catskill Front between Stroudsburg, Pennsylvania, and Albany, New York, was undertaken in 1938. At Stroudsburg the four Hamilton formations were recognized underlying Tully sandstone. Along the Delaware River at Port Jervis, New York, Moscow and Ludlowville formations are separated by the Portland Point member. The *Vitulina* zone at the top of the Hamilton was discovered on the Delaware River opposite Sparrow Bush.

Northeastward the top of the Hamilton was traced to Napanoch, but the upper two formations grade into plant-bearing nonmarine beds. The lower two formations, Marcellus and Skaneateles, here show a close-shore marine facies. West of Kingston nonmarine beds displace most of the Skaneateles, and west of Catskill the upper formations and part of the Marcellus grade into red beds. Thus along the Catskill Front between Napanoch and Catskill red beds (Kiskatom) displace all the Hamilton to the Ashokan sandstone which is nonmarine and of upper Marcellus age. The Mount Marion sandy shale below the Ashokan is a sandy facies of the Marcellus (Chittenango) shale. The thickness of the Hamilton increases from about 2600 feet at Port Jervis to about 3200 feet at Napanoch north of which the top of the group was lost in the red beds. If the rate of thickening between these two places is continued to Catskill the group must be 4000 feet or more thick which means that most of the mountain front west of Catskill is of Hamilton age.

LAND-FORM REGIONS OF NEW YORK STATE

BY GEORGE B. CRESSEY

New York State includes all or parts of nine geomorphic provinces and 31 regions, and the areas reflect lithology, structure, and history. Terminology of surface configuration needs classification; as here used the provinces are termed lowlands, uplands, or highlands, largely on the basis of relief.

The Adirondack Highlands, coextensive with pre-Cambrian rocks, embrace three regions—the Adirondack High Peaks (summits over 3000 feet), the encircling Adirondack Low Mountains (elevations over 1500 feet), and the Western Adirondack Hills.

The St. Lawrence-Champlain Lowlands include the St. Lawrence Marine Plain, the St. Lawrence Hills to the south, and the Champlain Lake Plain.

The New England Uplands comprise the Taconic Hills, Berkshire Hills, Reading Hills, and Manhattan Hills. Between the last two regions is the Triassic Lowland

province. The Harbor Hill-Ronkonkoma moraines and the Long Island outwash plain are regional units of the Atlantic Coastal Lowlands.

The Hudson-Mohawk Lowlands include the Hudson Valley and the Walkill Valley, continuations of the Valley and Ridge province, and the Mohawk Valley.

The Appalachian Uplands form the largest province, with traces of the Schooley peneplain on the upper surfaces. In the east are the Catskill Mountains, south of which are the Delaware Hills and the Shawangunk Mountains, while to the north are the Helderberg Hills. Farther west are the Susquehanna Hills, the Finger Lake Hills, the Cattaraugus Hills, and the unglaciated Allegheny Hills. The Tug Hill Upland is an outlier.

The Erie-Ontario Lowland has eight regions. The Erie Lake Plain, the Ontario Lake Plain, and the Oneida Lake Plain are the flattest. The Southern Ontario Hills are immediately north of the Allegheny Front in the west, while farther east are the Ontario Drumlins, the Ontario Ridge and Swamp Land, and the Eastern Ontario Hills. The Black River Valley is an extension of the province.

SIBERIAN RESOURCES FOR SOVIET WARFARE

BY GEORGE B. CRESSEY

The Urals and eastward into Siberia contain extensive resources of strategic value in the war with Germany. These appear adequate for a significant industrial output even though all of Soviet Europe should be occupied.

Coal reserves account for 90 per cent of the Union's 1,654,361,000,000 metric tons, and the annual Asiatic output is approximately 40 million tons, or 30 per cent of the Union total. Half of this is from the Kuznetz field of central Siberia. In the Urals bituminous coal is mined at Kizel, and lignite at Chelyabinsk; to the east are the Karaganda, Cheremkhovo, Bureya, and Vladivostok fields.

Petroleum production is rapidly increasing in the Emba area northeast of the Caspian, and between the Volga and the Urals. No important reserves are known in Siberia, except on Sakhalin.

Iron ore occurs in the Ural Mountains at Nizhni Tagil, Zlatoust, and Magnitogorsk, also south of the Kuznetz Basin and near the Amur River. Siberian production is a third of the Union total. Low-grade manganese is obtained in the Urals, in Kazakhstan, and near the Kuznetz Basin.

Copper is mined from porphyry at Kounrad and Djezkazgan near Lake Balkhash; it is also mined in the Urals. Lead and zinc have long been produced at Ridder in the Altai Mountains. Fair bauxite is mined in the Urals. Gold is produced from lodes in the Urals and from placers on tributaries of the Yenisei and Lena rivers, notably the Aldan; foreign estimates are 5 million ounces annually.

Exceptionally large reserves of potash occur at Solikamsk in the northern Urals, with a production of 2 million tons. Other resources include asbestos, magnesite, platinum, and chromium in the Urals, and nickel in the Urals and Yenisei Arctic.

GLACIAL EROSION AND THE BURIED WYOMING VALLEY OF PENNSYLVANIA

BY IRVING B. CROSBY

Engineering investigations on the Susquehanna River in Pennsylvania, in New England, and elsewhere have thrown new light on the factors controlling glacial erosion, especially glacial overdeepening, and show the importance of geologic structure and preglacial topography. Near Bingham, Maine, the ice sheet over-

deepened a northwest-southeast valley in a hard, massive crystalline schist with rectangular jointing but had little effect on a belt of soft slate striking transverse to the valley which was left as a ridge across the valley.

The buried Wyoming Valley on the Susquehanna River strikes parallel to the direction of ice movement and consists of several overdeepened rock basins in the coal measures separated by rock ridges, but the total amount of overdeepening, 150 feet, is less than has been previously assumed. Knowledge of the northward extension of this buried valley has been extended 15 miles up the north branch of the Susquehanna River by data obtained from engineering investigations which show that a buried valley, transverse to the direction of general ice movement, extends from West Pittston to Falls, a distance of 8 miles. This appears to be a continuous valley rather than a series of basins, and it is separated from the northernmost basin of the Wyoming Valley by a bedrock sill which rises at least 40 feet above the buried valley upstream. This buried valley ends in the vicinity of Falls, and above this point there is no evidence of glacial overdeepening.

DISAPPEARANCE OF THE LAST ICE SHEET IN MASSACHUSETTS BY STAGNATION ZONE RETREAT*

BY L. W. CURRIER

Detailed mapping of eight 7½-minute quadrangles in eastern Massachusetts, north of latitude 42°00′, by parties of the Massachusetts co-operative geologic project and widespread reconnaissance in intervening areas, supplemented by earlier published observations by Clapp, Fuller, Crosby, Brown, and others, indicates that the valleys contain a remarkable assemblage of ice-contact terraces, ice-hole deposits, "eskers," and other forms, but no apparent end moraines. The patterns of outwash deposits suggest that ice tongues stagnated in the valleys and disintegrated into countless blocks around and upon which outwash was deposited as graded valley trains. Ice-block positions are commonly indicated by swamps bounded by ice-contact terraces; most of the "eskers"—in large part as braided chains—are found in such swamps and probably filled open fissures. It is suggested that the border of the last ice sheet may have retreated as a stagnation zone. The width of the stagnation zone would be expected to vary somewhat from valley to valley across the general direction of ice advance but might be expected to have a general order of width over a large area. Measurements made by Jahns in the northernmost quadrangles, where topography seems most favorable for preservation of uninterrupted sequences, ranged up to approximately 5 miles. Such an interpretation of stagnation-zone retreat may explain the widespread ice-contact features and the apparent lack of end moraines over much of New England without recourse to earlier theories of general stagnation and down-wastage. Topography is inferred to be important in formation of a stagnant zone.

TILLS OF EASTERN MASSACHUSETTS*

BY L. W. CURRIER

Mapping of a large area in eastern Massachusetts has disclosed at least two till sheets, as earlier reported by Bryan for central and western Massachusetts. The upper till is commonly light gray to white, granular, loose, and strikingly fresh; the lower is brown, compact, hard, moderately indurated, and has marked cleavage.

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The brown contains a small amount of fine secondary materials in the matrix and on grain surfaces, and more decayed pebbles. Gray till has been found overlying the brown at several places, but the reverse order of superposition has not been found; at one of these exposures the lower (brown) till has an oxidation zone. Mixtures of the two are common, fragments of the brown appearing in a matrix composed largely of the gray. Both tills are distributed throughout the area. Drumlins are composed of the brown, often partly veneered with gray which is also commonly thickest on the south sides of the drumlins. Differences in the tills cannot be attributed to differences in bedrock distribution for the formations are chiefly siliceous crystallines (granite, paragneiss, quartzite, and conglomerate) in long parallel belts approximately normal to direction of ice advance, and neither till has a distinctive pattern of distribution. Two distinct ice advances, one probably late Wisconsin, are favored over Upham's theory of differences due to englacial and subglacial origins from a single ice sheet.

SCHEELITE DEPOSITS IN THE GREENHORN MOUNTAINS OF THE SOUTHERN SIERRAS

BY NELSON C. DALE

Scheelite deposits are found in and adjacent to the Greenhorn Mountain park of the Sequoia National Forest of Kern County, California. More specifically these deposits are found in the Cedar Creek Mining District, 52 miles east of Bakersfield, California, at elevations ranging from 5000 feet to 7000 feet above sea level. These geographic and topographic relations are best noted on the Tobias Peak Quadrangle.

Whether viewed by natural or ultraviolet light scheelite appears crystalline with square prisms or anhedral grains as disseminations in a groundmass of garnet, epidote, amphibole, pyroxene, quartz, calcite, pyrite, pyrrhotite, and molybdenite.

Its occurrence is principally with the quartz-epidote and garnet zones of the contact metamorphic limestones of a great roof pendant intruded by granitic (granodiorite-quartz diorite) members of the Sierran batholith. To a lesser extent scheelite is found in quartz veins or lenses in the associated marble or in veins or fault fissures along with epidote and garnet in the quartzites associated with the metamorphosed limestones.

The WO_3 content appears to be greatest near the contact where 0.59% and 0.42% have been recorded at two places on the same body along the strike. Away from the contact the percentages of WO_3 were obviously less.

STRUCTURE OF CENTRAL PART OF SAWTOOTH RANGE, MONTANA*

BY CHARLES DEISS

The Sawtooth Range is south of Glacier National Park and forms 85 miles of the Rocky Mountain front in northwestern Montana. The range averages 9 miles in width, consists of a broad northeastward-pointing arc, and extends north across the Saypo quadrangle which is being mapped on the scale 1/62,500 for the United States Geological Survey.

The sedimentary rocks exposed in the Sawtooth Range are approximately 4700 feet thick, are Paleozoic and Mesozoic in age, and are divided into nine formations: Pagoda, Steamboat, Switchback (Middle Cambrian), and Devils Glen (Middle (?) Cambrian); unnamed formation (Upper Devonian); Hannan (Mississippian); Ellis (Upper Jurassic); and Kootenai and Colorado (Lower and Upper Cretaceous).

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Three structural provinces occur in the central part of the range: an eastern province, characterized by westward-dipping high-angle to moderately low angle thrusts along which Hannan and Devonian limestones moved east over Cretaceous rocks, producing imbricated slices that increase in number northward; a central province, characterized by closely spaced, westward-dipping, high-angle thrusts, and by drag folding of the Devonian and Mississippian rocks that constitute the imbricated slices; and a western province, characterized by folded, low-angle overthrusts, above which the rocks are compressed into large open folds.

The structures were produced by stresses from the west during the Laramide orogeny. The mountains were peneplained during the Tertiary, when the east-west courses of the main streams were established. Uplift in the Pliocene? raised the range to its present altitude but did not cause additional deformation.

PROCESSES OF ICE DEFORMATION WITHIN GLACIERS

BY MAX DEMOREST *

Internal deformation of ice accompanying glacial flowage formerly has been explained by (1) regelation, (2) idiomolecular transfer, (3) foam cell melting, or (4) basal slip.

Processes 1, 2, and 3 acting separately or in combination apparently sufficed to explain known intergranular displacements and changes of grain shape and size. Inductive and deductive studies indicate that processes 1 and 2 are effective throughout a glacier, though probably most important within porous younger névé ice. Foam cell melting only activates regelation; however, it requires saline material which has not been demonstrated as common to all glaciers.

Basal slip is intragranular displacement, effective wherever basal planes of an ice grain parallel active shear stresses. Petrographic and petrofabric studies show that such favorable orientations develop in response to long-continued uniform stresses and that basal slip may be locally important.

A new process, provisionally called "instantaneous recrystallization," results from strain of the crystallographic lattice. Its operation simulates the instantaneous atomic and molecular reorganization that produces both twinning and polymorphic changes in many minerals. In glacier ice, however, neither twinning nor polymorphic changes seem to occur. The reorganization reproduces the same lattice structure but causes a change in grain shape and orientation to relieve stresses. Thus intragranular adjustments enable intergranular movements. Within the compact ice of irregular interlocking grains, such as occurs downstream from the névé fields, this process is probably the most important.

Experiment shows that deformation of ice, even at the surface of a glacier, is primarily a result of flowage rather than of discontinuous movements on discrete shear planes. (Geological Society project.)

GLACIAL DRIFT NEAR CANAAN, NEW HAMPSHIRE

BY CHARLES S. DENNY †

The drift is divisible into till, fluviatile sand and gravel, and deposits intermediate between these two.

* Introduced by Adolph Knopf.
† Introduced by J. W. Goldthwait.

The compact till is brownish gray; in a few deep sections it is bluish gray. An imperfect cleavage, parallel to the surface, is characteristic of the upper 10 feet and absent below. Particles larger than ¼ inch in diameter constitute not more than 5 per cent of the till in most exposures. Many of the stones in the till are slightly weathered. The brownish-gray indicates slight weathering to a depth of 10 to 20 feet.

Fluviatile and lacustrine sand and gravel form kames and kame terraces in the principal valleys. The valleys of the tributaries entering the westward-flowing Mascoma River from the north are almost devoid of kames, whereas its southern tributaries contain abundant kames whose upper limit is the level of the divide to the south.

On the valley walls and in the tributary valleys there is a discontinuous veneer of drift which contains varying amounts of boulders, pebbles, sand, silt, and fragments of till. The interfingering and irregular members of this deposit include fluviatile sand and gravel, lacustrine silt, solifluction debris (warp), and loose sandy till. These sediments were deposited along the contact of the downwasting ice sheet and the valley wall, derived in part from material from the glacier and in part by rain wash and solifluction from the valley sides. The origin of the sandy till is uncertain. (Geological Society project.)

WEATHERING OF GARNET AND OTHER HEAVY MINERALS IN SOURCE ROCKS

BY LINCOLN DRYDEN AND CLARISSA DRYDEN*

Problem: Lower Cretaceous sediments bordering Wissahickon schist of Maryland and Virginia are, at least in part, directly derived from the schist, as shown by: (1) content of staurolite, kyanite, "Wissahickon tourmaline," and rare sillimanite; (2) large size, freshness, and angularity of heavy-mineral grains; and (3) lack of any other near-by source for these minerals. However, garnet, abundant in the schist, is either absent from or very rare in the sediments.

Hypothesis: Possible explanations for disappearance of garnet (such as destruction during transportation or after deposition) are numerous, but weathering in the source rock (schist) is the only adequate postulate.

Method of testing hypothesis: Heavy-mineral separations were made from the schist in all stages of weathering. At each locality, insofar as possible, fresh rock, partly weathered rock, subsoil, and soil were collected, and counts of garnet and other heavy minerals made for each separation.

Result: In each profile studied, from fresh rock to more highly weathered, garnet shows a marked decrease in relative abundance compared with one or more of the following associated minerals: zircon, tourmaline, sillimanite, staurolite, and hornblende.

Conclusion: Intense or prolonged weathering of source rock (schist) before and/or during lower Cretaceous time seems sufficient to explain absence of garnet from sediments of that age.

General applicability of method: (1) for studying relative rates of weathering of heavy minerals; (2) for showing that certain resistant mineral species, though very rare in fresh crystalline rock, may be greatly concentrated in weathering. In sediments derived from such weathering products such species may be common or abundant. (Geological Society project.)

* Introduced by W. C. Krumbein.

STRUCTURE AND PHYSIOGRAPHY OF THE NORTH-CENTRAL WASATCH

BY A. J. EARDLEY

The sequence of pre-Cambrian, Paleozoic, Mesozoic, and Cenozoic formations of the north-central Wasatch is summarized, and six new formations of Cretaceous and Tertiary age are described. Stages of deformation in the Sierran-Laramide orogeny are: (1) uplift of the northern Utah highland with cross folding, and rise of the north flank of the Uintas in Morrison time; (2) thrusting in Montana time (Taylor thrust); (3) renewed thrusting in Montana time (Ogden thrust); (4) cross folding of thrust sheets and first major elevation of Uintas, also in Montana time; (5) renewed thrusting in early Paleocene (Willard thrusting); (6) gentle cross folding of Willard thrust sheet, second major elevation of Uintas, and folding of lower formation of Wasatch group around Coalville anticline in middle (?) Paleocene; (7) renewed gentle folding in upper (?) Eocene; (8) renewed gentle folding in upper (?) Oligocene; (9) Basin and Range faulting subsequent to erosion of the high Herd Mountain surface and the younger Weber Valley surface, a pediment. The faulting was followed by dissection and alluviation of the pediment, the rise and fall of Lake Bonneville, and post-Bonneville dissection.

The structures trend in three directions, and problems concerning their superposition are discussed. The local structures are correlated with the regional from the standpoint of chronological development and of distribution and orientation. Tuffaceous beds indicate five periods of volcanic activity in adjacent areas. (Geological Society project.)

STRUCTURE OF A PART OF WALKER MOUNTAIN, VIRGINIA

BY RAYMOND S. EDMUNDSON

Walker Mountain in southwestern Virginia is the northwest limb of a syncline which is progressively overridden by a thrust sheet toward its southwestern end. About 6 miles northeast of Abingdon, Washington County, the structure is concealed by a sheet of Honaker dolomite thrust from the southeast. A complete section of the mountain includes Cambrian to Upper Devonian strata dipping steeply to the southeast. Farther southwest in Tennessee along Bays Mountain, which is in strike with Walker Mountain, the magnitude of the fault diminishes, and both limbs of the syncline are present.

Of special interest are numerous cross faults of small displacement near the southwestern end of Walker Mountain. These emerge from beneath the thrust or in some places offset the trace of this fault. Resistant Silurian sandstones (Clinch and Clinton) thin gradually toward the southwestern end of the structure and are absent along the belt characterized by cross faulting. The absence of these rocks may have contributed to a weakened zone which failed by cross faulting during the deformation.

LITHOLOGY OF THE SEA FLOOR OFF SOUTHERN CALIFORNIA

BY K. O. EMERY AND F. P. SHEPARD

Collections of rock obtained from the sea floor off the southern California coast principally through the 1938 cruises of the E. W. SCRIPPS have been studied in the laboratory, and their petrographic character and fossil content have been determined. Rock was obtained from a total of 130 localities in such environments as

the narrow continental shelf, the walls of submarine canyons, escarpments, and hills.

Because of large size, angularity, quantity of fragments in a single haul, and the presence of fresh fractures many of the samples are thought to be representative of the bedrock outcropping at the sampling locality. The material recovered includes sedimentary, igneous, and metamorphic types. Ages were determined partly by fossil content and partly by lithological comparison with rocks outcropping on the adjacent land. Triassic-Jurassic, Cretaceous, Eocene, Miocene, and Pliocene were all represented, with Miocene rocks by far the most common. The igneous rocks are predominantly andesite, although some basalt was found. The chief conclusion from this reconnaissance work is that the submerged basin and range province off the southern California coast is lithologically remarkably similar to that of the bordering land areas. (Geological Society project.)

MONROE FAULT OF NEW HAMPSHIRE AND VERMONT

BY JOHN H. ERIC, WALTER S. WHITE, AND JARVIS B. HADLEY*

A distinct change in lithology occurs in the vicinity of the Connecticut River in northern New England, and geologists working in this region have contrasted "New Hampshire" stratigraphy with "Vermont" stratigraphy. This sudden lithologic change is due to the Monroe fault, evidence for which is clearest near Monroe, New Hampshire.

The fault trends N. 20° E. and has been located accurately from Granby, Vermont, to Norwich, Vermont, a distance of about 72 miles; it probably extends at least 50 miles farther south and an unknown distance to the north.

Regional mapping shows truncation of formations along the fault. Moreover, 5 miles north of Concord, Vermont, northwestward-trending strata southeast of the fault strike into northeastward-trending beds northwest of the fault. Three quarters of a mile north of Monroe, New Hampshire, the fault crosses a 450-foot ridge, and detailed mapping, as well as direct observation of the fault plane, shows that the dip is 65° northwest, essentially parallel to the schistosity in the adjacent formations. The average dip throughout the area mapped, however, is believed to be about vertical. The initial dip may have been much gentler, and the present attitude may be due to later folding. Most of the movement along the fault preceded the metamorphism.

The rocks directly southeast of the fault are pre-Silurian. Those directly northwest are of unknown age; if they are Devonian, as some believe, the southeast side of the fault is upthrown; if they are pre-Silurian and older than the rocks to the southeast, the northwest side is upthrown.

GLACIAL MAP OF NORTH AMERICA—I: INTRODUCTION; II: NORTHWESTERN UNITED STATES

BY RICHARD FOSTER FLINT

The final manuscript draft of the Glacial Map of North America is expected to be completed within about 6 months. Compilation and study of the glacial data from northwestern United States make clear a number of relationships. Those discussed below are the combined work, published and unpublished, of many geologists.

The extent of glaciation in Washington and northern Idaho is well known except

* Introduced by M. P. Billings.

in large areas of the Cascade Mountains. Three drifts and one interglacial have been recognized. The latest (later Wisconsin) drift records three major glacial lobes—Puget, Okanogan, and Spokane—each apparently of piedmont type.

In Montana the extent of mountain glaciation is better known than in the Cascades. Three drifts are recognized, the oldest much older than the other two. Across the plains of eastern Montana there are at least two distinct drifts of Keewatin derivation: later Wisconsin and Iowan or Illinoian. Extraglacial lakes beyond both drift borders are conspicuous.

In North Dakota and South Dakota the extent of glaciation is less well known than in the States to the west. The drift borders in most sectors are only approximate, and accurate field determination of them is urgently needed. Apparently three drifts are present: Iowan or Illinoian, an intermediate drift, and later Wisconsin, the border of the last being marked by the so-called "Altamont moraine". In eastern South Dakota two distinct glacial lobes are recorded, related respectively to the James River and Des Moines River basins.

GLACIATION OF SHICKSHOCK MOUNTAINS, GASPÉ PENINSULA

BY RICHARD FOSTER FLINT, MAX DEMOREST, AND A. LINCOLN WASHBURN

The Shickshock Mountains constitute one of the highland areas that have been considered by Coleman on geologic evidence and by Fernald on botanical evidence to have been nunataks during the maximum of the Wisconsin glacial age.

Recent field studies have been made on the two highest parts of the Shickshocks: the broad plateaulike masses known as Mount Albert (summit altitude 3775 feet) and Tabletop Mountain (4230 feet). Glacial erratics believed to be pre-Cambrian rocks from north of the St. Lawrence were found as high as 3760 feet on Mount Albert. On Tabletop Mountain, striated surfaces were found as high as 3500 feet, and glacial erratics (of local origin) as high as 3700 feet. Detailed search failed to produce any direct evidence of glaciation through the highest 530 feet. Throughout this vertical distance evidences of any possible glaciated surfaces are obscured by mantles of locally derived felsenmeer that presumably originated in postglacial time. In addition, the composition of the bedrock is so heterogeneous that several types of erratics might be present without having been recognized. These circumstances do not demonstrate glaciation of the highest parts of Tabletop Mountain, yet there is no geologic evidence inconsistent with the view that the entire Shickshock highland was overtopped by Wisconsin ice. No geologic evidence was found suggesting that any portion of the area existed as a nunatak during the Wisconsin maximum.

After and probably also before the invasion by Labrador ice, Tabletop, at least, was a center of radial outflow from a local ice cap.

CHROMITE DEPOSITS OF THE PHILIPPINE ISLANDS

BY DEAN F. FRASCHE*

The chromite deposits of the Philippines occur in isolated masses of ultrabasic rocks which are in general found along the eastern and western borders of the Island group. The ultrabasic rocks are highly serpentinized and are difficult to distinguish in the field, but petrographic studies reveal them to be composed essentially of three intergrading rock types—dunite, saxonite, and pyroxenite. Of

* Introduced by W. D. Johnston, Jr.

these three types, saxonite occurs in greater volume than either dunite or pyroxenite. Varying amounts of chromite are found in the different rocks, but the known commercially important deposits appear to be confined entirely to the serpentinized dunite. Locally in the Zambales area, gabbro and diorite intrude the chromite deposits, but these less basic rocks appear to be confined to the refractory grade ore bodies. The chromite is considered to be genetically related to the dunite and is probably of early magmatic origin.

Although chromite occurs in commercial quantities on several of the Islands, the largest deposits are found in Zambales Province, Luzon. The individual deposits vary greatly in size, ranging from a few hundred to more than 10 million metric tons. The grades of chromite now being produced in the Zambales area are classified according to their industrial uses—namely, metallurgical ores, chemical ores, and refractory ores.

Philippine reserves of chromite of all grades are estimated to be 10,890,500 metric tons. Of this total 10,120,000 metric tons are refractory grade, 450,500 tons are chemical grade, and 320,000 tons are metallurgical or submetallurgical grade.

JALAUR LANDSLIDE, ISLAND OF PANAY, PHILIPPINES

BY F. M. FRYXELL

A journey into interior Panay in February 1940 permitted examination of a major landslide previously known only from scant reports of natives.

The landslide is in a sparsely populated district in central Panay, 21 miles west of Calinog, nearest barrio. Maturely dissected mountains are developed in east-dipping Tertiary sands and clays. The meandering Jalaur River is entrenched several hundred feet, and local oversteepening of weak bedrock has caused many landslides. An additional factor applying to the Jalaur landslide may have been local clearing by burning off vegetation (the *kaingin* system, widely practiced by primitive natives).

On November 24, 1938, late in the rainy season, a north bluff about 500 feet high suddenly collapsed and dammed the narrow valley below. A landslide of the slump type resulted, subsidence of several distinct but irregular blocks giving the north slope a stepped profile. Several houses were destroyed, and 15 mountaineers perished.

As the impounded water rose behind the obstruction, mountaineers abandoned their homes and sought the hills. At Calinog opinions concerning flood danger conflicted sharply; nevertheless many residents moved to higher ground. On December 27, when the lake was 33 days old, was 5 miles long, half a mile wide, and 180 feet deep, it burst its barrier. The resulting flood swept the Jalaur valley for at least 25 miles. Available accounts mention no loss of life, but damage to property was considerable, especially in Calinog.

Only an expansion of the Jalaur River now marks the site of the 1938 lake.

1941 MUDFLOWS IN THE TETON RANGE, WYOMING

BY F. M. FRYXELL AND LELAND HORBERG

A summer of record precipitation in the Tetons was climaxed by the formation of nearly 100 mudflows. Their simultaneous and unexpected appearance during several torrential August rains was sequel to 2 months of rains which already had nearly saturated detrital deposits.

Most mudflows developed below talus cones. Torrents discharging from couloirs above gullied the cones, even those brush-covered, and from the gulley mouths below issued saturated mixtures of rocks and mud, as lobes, sheets, or anastomosing streams of debris. Several large mudflows have upper slopes of 15° and flatten to 3° at their edges. Boulders 4 feet across were transported on the mudflows to their steep, abrupt fronts.

In lower Leigh Canyon, converging mudflows floored the canyon and pushed downstream a quarter of a mile, wiping out scrub forest. Higher, the canyon was dammed in two places, one mudflow 700 feet wide impounding a lake 1000 feet long. Other canyons were similarly modified, especially Cascade and Moran canyons.

No such phenomena have previously been noted within the writers' period of observation, since 1925. Events of 1941 demonstrate that occasionally alpine mudflows may suddenly originate in large numbers and locally assume importance overshadowing many other geomorphic features. They then play a significant role in moving rock debris into the central part of the canyon, the zone of stream attack. Here they soon lose their characteristic form as the mud matrix is swept away and the boulders are distributed downstream. Many bouldery canyon deposits are probably referable to old mudflows no longer recognizable as such. (Geological Society project.)

GEOMORPHOLOGY OF THE TETON RANGE AND ADJACENT BASINS, WYOMING-IDAHO

BY F. M. FRYXELL, LELAND HORBERG, AND RUDOLPH EDMUND

The Teton Range, notable example of a fault-block range, was involved in Laramide folding and faulting, followed by uplift and tilting along a Tertiary high-angle fault of over 8000 feet displacement. Tertiary faulting was post-Oligocene.

No surfaces certainly referable to the Fremont cycle remain, but a former summit peneplain is postulated to explain the course of Webb Creek, which crosses an axis of uplift, probably due to superposition. Surfaces of Union Pass and Black Rock age are well represented; mature surfaces in the alpine pre-Cambrian region are correlated with the Union Pass. Locally, the pre-Cambrian surface has been exhumed.

This erosional picture is consistent with regional relationships, leading to belief that the present Teton Range has been exhumed and its east slope is primarily a fault-line scarp. Tertiary beds in Teton Basin suggest that this lowland, like Jackson Hole, is due to differential erosion.

Asymmetry of the Teton block has resulted in westward migration of the divide and isolation of the high peaks. Certain canyons are consequent, others reflect structural or lithologic adjustment.

Buffalo ice extended lobes into both Teton Basin and Jackson Hole, probably from the Absaroka region. Converging Bull Lake valley glaciers expanded in Jackson Hole. Pinedale valley glaciers were well developed only on the Teton east slope; impressive sculpturing reflects influence of foliation and jointing, and contrast between glaciation of shaded and sunny slopes.

Moraines of 10 existing glaciers are correlated with protalus ramparts in ice-free cirques. Rock falls, rock glaciers, and mud flows record activity of present agencies. (Geological Society project.)

MINERALIZATION OF THE AJO COPPER DISTRICT, ARIZONA*

BY JAMES GILLULY

The New Cornelia ore body at Ajo is a deposit of chalcopyrite with subordinate bornite and other minerals disseminated in a mass of quartz monzonite porphyry of early Tertiary (?) age. Petrographic study shows that the ore body lies in part of the porphyry with a peculiar groundmass texture that is believed to date from a time prior to consolidation. Pegmatites of probable replacement origin were formed later, and the monzonite surrounding them was heavily impregnated with finer-textured potash feldspar and quartz. Sulphide impregnation, which followed, is heaviest in and near the pegmatites and fades out into a zone of sericitization peripheral to the zone of feldspar impregnation. The mineralization is believed to have been by an unbroken continuation of magmatic evolution into a hydrothermal stage. No discontinuities are recognized in the sequence of alterations that linked the magmatic stage with that of sulphide mineralization, although specular hematite, which is very abundant, seems clearly governed by different controls and may record a discontinuous—pneumatolytic—stage. It is uncertain but appears probable that sulphide mineralization and hydrothermal alteration reverted to their former controls after the period of specularite formation.

Weathering of the deposit has taken place in two stages: an earlier, during which there was notable downward enrichment, and a later, during which the copper was oxidized essentially in place. Between the two periods, the block containing the deposit was tilted about 60°. No satisfactory explanation of the different behavior during the two erosion cycles has been discovered.

TWO (?) TILLS IN NEW HAMPSHIRE

BY LAWRENCE GOLDTHWAIT †

Recent deep exposures of glacial till in New Hampshire show two distinct tills, aside from the normal soil zone. The color contrast is strong, and the contact between the brown and blue till is sharply defined. The problem of origin of the two is thus reopened. These tills may have been formed (1) by deposition from two ice advances, (2) by deposition from one ice advance, the upper till having come farther, as englacial drift, and come to rest upon the lower, subglacial drift, or (3) by deposition of a single sheet of till, followed by postglacial weathering.

In a survey of tills for the New Hampshire Highway Department, 85 samples have been taken from 65 localities. From these, the wet and dry densities have been determined, and stone counts made. Microscopic mineral analyses and specific gravity studies are being made on selected samples, especially those taken in vertical series. Grain-size distribution curves have been determined by sieve and Boyoucous hydrometer methods.

Wherever sections go deep enough, light-brown or drab till is found above (not below) blue till, with a sharp contact between the two at a depth consistent with the water table. This contact in places is marked by a strong concentration or crust of limonite. Aside from color, however, the two tills are much alike. Evidence therefore points to one till deposit that has been discolored and other-

* Published with the permission of the Director, Geological Survey, U. S. Department of the Interior.
† Introduced by J. W. Goldthwait.

wise slightly weathered to depths several times greater than the usually accepted shallow 2-foot oxidized zone.

FLOOD PLAINS OF NEW HAMPSHIRE RIVERS

BY RICHARD P. GOLDTHWAIT*

Three meandering sections of river, each about 20 miles long, are being studied for the New Hampshire State Highway Department. Historic changes in the course of each river over its flood plain are plotted from old maps, lot plans, and written accounts. Similar changes for the prehistoric period are worked out from the sequence of truncations of scroll ridges by fitting together sets of scrolls at similar heights from one curve to the next. These rivers began their present cycle of erosion upon glacial lake and outwash deposits, and the number of meanders present on the rivers may have been greatest at the initial stage.

Most of the eating away of meander banks occurs in short periods at least once a year at times of moderately high water. Erosion of the floodplain surface, and swirl pits in particular, occur less frequently since they require sheetlike movement of the water over high flood plain. Construction of the flood plain, as noted in deposits in progress and in stratification in exposed banks, consists of these increments: coarse cross-bedded channel gravels below water, gravel or sand current ridges arranged en echelon around each inside meander curve, sharp scroll ridges of sand and silt built at high-water time on each slip-off slope, layers of high flood sands which tend to reduce the relief of underlying scrolls, and laminated ground-water deposits along channel banks.

AUTORADIOGRAPHY OF ORES

BY CLARK GOODMAN AND GEORGE A. THOMPSON

Using stray slow neutrons from the Massachusetts Institute of Technology cyclotron on elements having large nuclear cross sections for (n, γ) reactions and yielding radioactive isotopes of convenient half periods, autoradiographic studies of a number of ores have been made. The locus and relative concentrations of these elements in the constituent minerals are determined by placing polished sections of the activated ores in direct contact with photographic film. The source of the effective β-radiation is ascertained from the decay rate and intensity of the activity. Manganese-, gold-, cadmium-, and phosphorus-bearing ores have been studied by this method. Further investigations are in progress with the purpose of extending the method to other elements, of making the method quantitative, and of applying the method to thin sections.

REPLACEMENT APLITE BRECCIA

BY G. E. GOODSPEED AND RICHARD E. FULLER

A cross-cut tunnel at Cornucopia, Oregon, recently intersected a brecciated zone, 125 feet wide, in granodiorite, about 2000 feet below the surface. This zone, which dips steeply, is well within the granodiorite about a mile west of the main hornfels contact. The margins of many of the granodiorite fragments (the largest are about 2 feet across) grade into a relatively coarse-grained pinkish aplite.

* Introduced by J. W. Goldthwait

Some fragments are entirely aplite with shadows or relics of granodiorite. Fine-grained aplite, locally also brecciated, heals many of the fractures, although some actual voids remain. Many of the irregular fractures are filled with radiating clusters of actinolite associated with carbonate, biotite, muscovite, zoisite, sphene, and chlorite, and with local intergrowths of quartz and feldspar. In the voids well-formed crystal faces are common.

The breccia, numerous slickensides, and mylonitic microstructures indicate movement. The brecciation of the later aplite shows continuance of movement. Gradational contacts between aplite and granodiorite, and between the finer and coarser aplite, relics of granodiorite in the aplite and of coarser aplite in the finer aplite, association of mylonitic microstructures with the finer aplite, voids between the granodiorite fragments, coupled with a lack of magmatic flow structures or chilled borders, strongly suggest that the aplite is hydrothermal and that replacement has been important in its formation. Most of the interstitial mafic minerals are considered to have been derived from the original mafic constituents of the granodiorite upon its replacement by quartz and feldspar.

WASTING STAGNANT ICE NEAR LAKE PLACID, NEW YORK

BY CLARENCE E. GORDON

In features of topographic form, structure, arrangement, and distribution various deposits near Lake Placid, belonging to late waning stages of the last glacial ice of the region, suggest that they were developed under the control of residual melting ice. It is believed that the ice wasted by down-melting, accompanied by lateral shrinkage and frequently by mass disintegration, and that a variety of features may reasonably be explained by invoking such methods of ice behavior. The word "contact" is used in a broad sense, not only for somewhat regular ridge and terrace slopes but also for hillside veneers and irregular kame features associated with sloping plains, as well as for composite, uneven drift masses accumulated in the proximity of disintegrating ice.

It is suggested that Lake Placid village ridge was formed in an expanding fissure within the ice; that the broad kame terrace east and northeast of Mirror Lake was built as the ice shrank from the bordering hilly land; that in places successive periphero-marginal kame features and plains laid down in ponded waters were formed as the ice shrank laterally in more or less regular fashion; and that many areas experienced "fragmentation" of the ice and developed a hummocky topography made up of boulder drift and fluvial materials.

Lake Placid, Mirror Lake, and a few small depressions represent lingering masses of ice.

It is thought that the meltwaters leaked away to distant outlets at different levels by devious channels around the margins of the ice.

GLACIAL MAP OF NORTH AMERICA—VII: LOCAL CORDILLERAN GLACIATION

BY L. M. GOULD

Glaciation of the Cordilleran States south of the main ice sheet reached its greatest development in the Sierra Nevada, Cascades, and Rocky Mountains. However, the highest mountains of the Cordilleran States and even the High Plateaus of Utah were glaciated to varying degrees. Though much careful and exacting work

has been done in these States, in many places the glacial observations have been incidental to other aspects of geologic work. Accurate maps showing glacial geology are much less abundant than the recorded evidences of glaciation. The generous co-operation of many modern investigators has offset this lack in part by making available for inclusion in the forthcoming map a great deal of unpublished material.

Multiple glaciation has been noted in many areas. Evidence of two glacial stages is widespread. In some places three and in the Sierra Nevada even four stages have been reported. The differentiated areas of pre-Wisconsin drift are too limited to be mapped separately on the present map scale. All older drifts are therefore grouped as a unit. Following the generally accepted chronology of the Upper Mississippi Valley the Iowan is regarded as of Wisconsin age.

The sources and directions of ice movement are generally apparent from the distribution of the drift and other mapped records of glaciation. To avoid confusing and unnecessary detail, terminal moraines and symbols indicating the direction of ice movement are therefore omitted except where such omission would lead to ambiguity.

LIMESTONE COASTS OF THE TROPICAL PACIFIC

BY J. EDWARD HOFFMEISTER AND HARRY S. LADD

Many limestone areas in Fiji and Tonga were elevated from the sea during the closing stages of the Tertiary and have been subjected to erosion since that time. Heavy rainfall, luxuriant vegetation, and the originally porous nature of the limestones favor the operation of atmospheric solution. All drainage finds its way to the sea underground, forming a rugged type of karst topography in which stream-cut valleys are entirely absent. It appears that solution effects are carried an appreciable distance below sea level as a lenticular mass of fresh water underlies each island. During parts of the Pleistocene when sea level was lowered these effects were carried to still greater depths.

Large sinkholes located near the coast have been transformed into bays by wave action. Such bays have narrow, shallow mouths. All stages in this bay-forming process may be recognized in the field.

The resulting irregular coast lines have frequently been taken as evidence of subsidence of the land. It is believed that in many cases these irregular shore lines are merely the result of solution and wave cutting.

NEBRASKAN-KANSAN DRIFT BOUNDARY IN MISSOURI

BY CHAUNCEY D. HOLMES*

Development of late-mature topography has involved removal of the Kansan drift sheet from extensive areas in northwestern Missouri, and the present land surface there bevels the Nebraskan gumbotil horizon. In north-central Missouri, the Grand River and its larger tributaries have cut through the Kansan deposits, developing a pronounced digitate boundary between the two drifts and leaving numerous Kansan outliers on the higher divides. Kansan gumbotil caps extensive tabular divides eastward from the Chariton River valley, but many of the deeper valleys between these divides expose inliers of Nebraskan drift. In places, the bedrock surface lies higher than the adjacent Nebraskan gumbotil horizon.

* Introduced by E. B. Branson.

Kansan drift apparently overlapped the Nebraskan deposits southward along the limit of glaciation, though present data are inadequate for accurate age determination along the glacial boundary.

At some localities, the Aftonian horizon is marked by sandy and gravelly silts presumably of fluvial origin. Similar materials of widespread occurrence beneath the Kansan drift rest on bedrock and may be preglacial. (Geological Society project.)

IGNEOUS ROCKS OF THE NORTHERN QUITMAN MOUNTAINS, TRANS-PECOS TEXAS

BY ROY M. HUFFINGTON*

Igneous rocks of the northern Quitman Mountains consist of both extrusives and intrusives. Over 2500 feet of early Tertiary flows and pyroclastics lie in the center of the mountains and uphold the highest peaks. Later basining, probably due to magmatic subsidence below the volcanics, has dropped the central portion of the volcanics at least 1000 feet, giving flows along the outer contacts inward dips as high as 90°; average inward dips range from 30° to 45°. A discontinuous ring of granitic intrusives surrounds the volcanic area and appears structurally to be a modified ring-dike with an accessory stock at the north end. Previous interpretation of the intrusive as a batholith arose from the erroneous idea that the volcanics were intrusive porphyries.

The volcanics range from a basalt to trachytes and rhyolites; the latter are most abundant. The earliest intrusion in the area was a diorite, of which only three outcrops remain. The main intrusion averages a quartz monzonite. Plugs and dikes of aplite, granite porphyry, rhyolite porphyry, and quartz latite porphyry are the latest phase and cut all other rocks.

Though extensive prospecting has disclosed many scattered small deposits of various ores, mining has proved unprofitable.

STRATIGRAPHY AND STRUCTURE OF THE NORTHERN QUITMAN MOUNTAIN AREA, TRANS-PECOS TEXAS

BY ROY M. HUFFINGTON*

The northern Quitman Mountains lie in the Sierra Madre Oriental province where it projects northward from Mexico into Hudspeth County, Texas. Permian strata of the Briggs formation have a maximum exposed thickness of about 200 feet. Unconformably overlying the Briggs is the Malone formation (0 to 100 feet thick) of Jurassic age. The Trinity and Fredericksburg groups of lower Cretaceous age are represented by the following formations, for which the maximum exposed thicknesses are given: Torcer (300 feet), Yucca (5500 feet), Bluff (about 1800 feet), Cox (700 feet), and Finlay (100 feet). The Washita group, also of lower Cretaceous age, has a maximum exposed thickness of 680 feet, giving the lower Cretaceous section in this area a maximum aggregate thickness well over 9000 feet. The true stratigraphic position of the Etholen conglomerate, with a maximum thickness of 500 feet, is found to be either latest Washita or early Eagle Ford.

Folding and faulting are intense in the northern Quitman area. Three thrust faults—the Devil Ridge, Red Hills, and Quitman—have a total displacement of more than 8 miles and break the eastern area into distinct topographic blocks. The largest normal fault has a displacement of more than 1000 feet; the others are much

* Introduced by M. P. Billings.

smaller. In Quitman Gap at the southern part of the area 7000 feet of lower Cretaceous sedimentary rocks is overturned, locally as much as 200°, on the east limb of a large anticline. The main orogenic disturbance is probably late Cretaceous.

GEOLOGY OF SOME MOUNTAIN RANGES EAST OF THE SALTILLO BASIN

BY WILLIAM E. HUMPHREY*

Into the Saltillo Basin of southeastern Coahuila plunge the westward-trending ranges of the Sierra Madre Oriental. Rugged, anticlinal uplifts of Upper Jurassic and lower Cretaceous strata alternate with synclinal valleys of upper Cretaceous shales. Near-shore deposits—sandstone and conglomerates—point to the proximity of the Coahuila Peninsula strand line or to rising island masses in the Tithonian? and Portlandian seas. The ammonite fauna from the Gargasian zone of *Dufrenoya dufrenoyi* (D'Orbigny) is described, and the beds are correlated with formations elsewhere in Northern Mexico and in Texas. Most of the structural elements are overturned to the north as part of a Laramide movement toward the ancestral massif of the Coahuila Peninsula. The plunging western ends of the anticlines are symmetrical or very slightly asymmetrical with the steeper dips to the north, but in their middle portions the folds become complicated, commonly showing overturning and fanfolding. Some small thrusts are noted, but large-scale overthrusting is conspicuously absent. North-south normal faults bound salients of greater overturning along the flanks of the folds and are probably responsible for the positions of most of the cross canyons in the area studied. Ore bodies of lead-silver replacements in dolomitic limestones are located along these normal cross faults or along the axes of the anticlines.

PROPOSED HELIUM TIME SCALE

BY PATRICK M. HURLEY AND CLARK GOODMAN †

Sufficient determinations on minerals believed to retain radiogenic helium have been completed to outline a new helium time scale. The main points in the proposed scale are based on (1) numerous geologically contemporaneous samples of broad geographical distribution, (2) agreement in age between samples of widely different radioactive content and Th/U ratio, (3) at least duplicate measurements on each sample, and (4) agreement in age between different mineral species of the same geologic age. (Geological Society project.)

LATE JURASSIC FOSSILS FROM THE VIÑALES LIMESTONE OF CUBA

BY R. W. IMLAY **

Study of a large collection of ammonites and aptychi made by geologists of the Atlantic Refining Company from the Viñales (Aptychus) limestone of Cuba shows that the limestone is of Portlandian rather than early Cretaceous age and contains faunal elements closely related to those of Mexico and South America. The fossils include 21 species of normal ammonites, 4 of uncoiled ammonites, 7 of aptychi, and 1 cephalopod beak. Diagnostic genera include *Hildoglochiceras, Simoceras, Aspidoceras, Physodoceras, Virgatosphinctes, Parodontoceras, Corongoceras, Durangites,*

* Introduced by L. B. Kellum.
† Introduced by W. J. Mead.
** Introduced by J. B. Reeside, Jr.

Lytohoplites, and *Pseudolissoceras*. Of these, the last four are known only from the Portlandian. Previous correlations with the Lower Cretaceous were based mainly on identity of the aptychi and similarity of the uncoiled ammonites to species in the early Cretaceous deposits of the Alpine-Mediterranean region. Association of the aptychi and the surprisingly abundant uncoiled ammonites in the same beds with normal ammonites permits no doubt as to their Portlandian age and suggests that aptychi must be used with caution in stratigraphic work. The fossils are definitely not of Kimmeridgian age and are decidedly younger than the upper Oxfordian-lower Kimmeridgian fossils described by Sanchez Roig and Marjorie O'Connell. Furthermore, the study substantiates the contention of Roy E. Dickerson and W. H. Butt, 1935, that the older fossils are from the San Cayetano formation but are mixed locally with float from the overlying Viñales limestone. It shows that the angular unconformity claimed to exist between these formations was developed during Kimmeridgian time.

OUTWASH CHRONOLOGY IN NORTHEASTERN MASSACHUSETTS*

BY RICHARD H. JAHNS †

Detailed studies of outwash deposits in the Ayer, Tyngsboro, and Lowell quadrangles in northeastern Massachusetts support the concept of a receding sheet of relatively solid ice which had, at its irregular outer margin, a zone of discrete, broken-up, and essentially motionless ice masses. Kame terraces, ice-contact plains, and other graded forms have been carefully leveled and correlated.

The deposits have been grouped; each group within a single valley appears to represent deposition from meltwaters graded to a constant level generally controlled by a bedrock threshold. Each group is somewhat analogous to an outwash plain, except that surface continuity is much broken by large, irregular ice-block areas. The head of any group is taken to indicate the locus of points of outwash deposition nearest the solid ice immediately prior to the lowering of meltwater level and development of a new outwash group, presumably through sudden uncovering of a lower drainage path.

The length of a given outwash group measured parallel to the direction of recession indicates the approximate minimum width of the "stagnation zone" at the end of active sedimentation in that group. This distance is measured from the highest outwash deposit to the lowest down-drainage position of an ice mass that was not completely covered. Widths range from 1 to 4½ miles, with an average of about 3 miles.

STRATIGRAPHY OF THE LOWELL-FITCHBURG AREA, MASSACHUSETTS*

BY RICHARD H. JAHNS †

A thick sedimentary section, part of the series of late Paleozoic strata that extends from the Worcester area into southeastern Maine, is invaded in the Lowell-Fitchburg area by many quasi-conformable igneous masses of noritic to granitic composition. Southeast of Ayer the beds strike northeast and dip very steeply as a homoclinal series. They appear to become progressively younger to the southeast, with a sequence as follows:

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† Introduced by L. W. Currier.

Stratigraphic unit	*Probable thickness* (in feet)	*Name used by Emerson*
Coarse-grained muscovite-biotite gneiss with thin limestone beds; many amphibolite members	At least 12,000	"Bolton" gneiss
Fine-grained quartz-sericite-andalusite schist	3600-4500	Brimfield schist
Conglomerate with pebbles of quartzite and slate	0-600	Harvard conglomerate
Impure quartzite and arenaceous phyllite	At least 6000	Merrimack quartzite

The base of the Merrimack is not exposed in the areas studied, but its upper strata are the equivalent of beds previously mapped as Oakdale quartzite in the area west of Groton. The Harvard conglomerate is truly basal to Emerson's Brimfield schist and contains pebbles that appear to be of Merrimack quartzite. The normal sedimentary contact between the Brimfield schist and "Bolton" gneiss, clearly exposed near Littleton, precludes a pre-Cambrian age assignment for the latter. If the Merrimack and Brimfield are Carboniferous, as seems probable, Emerson's interpretation of a late Paleozoic age for the "Bolton" seems entirely justified.

PALEOZOIC ROCKS OF CENTRAL AND EAST-CENTRAL VERMONT*

BY RICHARD H. JAHNS AND WALTER S. WHITE†

One of the thickest Paleozoic sections in the world is exposed between the Green Mountains and the Connecticut River in central and east-central Vermont. The rocks occur in general as a steeply dipping homoclinal series. They strike north to northeast over most areas and become progressively younger from west to east. All strata between the Mad River-White River valley and the Connecticut River are probably of pre-Carboniferous Paleozoic age and appear to represent a total thickness of at least 65,000 feet in the latitude of Waitsfield, Barre, and Woodsville.

Despite their simple major structure, the rocks have been severely deformed and metamorphosed and have been intruded by stocks, dikes, and small plugs of granite, diorite, diabase, and peridotite. Regional metamorphism, which clearly bears no direct spatial or temporal relation to the principal tectonic activity in the area, has resulted in development of new mineral suites that with few important exceptions are characteristic of the low-grade and middle-grade zones.

The lower half of the section is essentially noncalcareous and includes slates, phyllites, quartzites, arenaceous schists, and silicic and intermediate volcanics. Impure crystalline limestones and dolomitic limestones of the Waits River formation are common in the upper half. All of the strata appear to have been laid down in a relatively narrow, rapidly sinking Paleozoic geosyncline.

GLACIAL MAP OF NORTH AMERICA—III: WEST-CENTRAL UNITED STATES

BY G. F. KAY AND L. M. GOULD

The west-central States include Minnesota, Iowa, Missouri, Kansas, Nebraska, North Dakota, and South Dakota.

Most of Minnesota is covered by Mankato drift, with broad areas of Iowan drift extending beyond the Mankato into southwestern and southeastern Minnesota. Drift called "old red drift," south and east of St. Paul and mapped Illinoian, is largely,

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† Introduced by L. W. Currier.

if not wholly, overridden by Iowan drift. Beyond the Iowan is Kansan drift, beneath which in southeastern Minnesota is Nebraska drift.

In Iowa, Nebraskan, Kansan, Illinoian, and Wisconsin drifts are present. Nebraskan drift covered the whole State; Kansan drift, too, covered the whole State except the northeast. Illinoian drift is limited to southeastern Iowa; and drifts of the Iowan and Mankato substages of the Wisconsin stage are in north-central Iowa.

In northwestern Missouri essentially all drift now exposed is Nebraskan, the Kansan having been eroded. Farther south the Kansan drift is more widespread. In north-central Missouri a pronounced digitate boundary separates the extensively preserved Kansan drift of the uplands from Nebraskan drift in valleys of the Grand River and its tributaries.

Kansan drift extends into northeastern Kansas. West of the Kansas River and west of Big Blue River, only scattered deposits of drift and isolated boulders are present.

In Nebraska, Nebraskan and Kansan drifts are present, each extending westward from the Missouri River into Nebraska 60 to 80 miles.

Mankato drift of North Dakota extends into South Dakota. East of the Mankato, Kansan drift and Iowan drift cover eastern South Dakota.

ALLEGHENY SYNCLINORIUM AND APPALACHIAN GEOSYNCLINES

BY G. MARSHALL KAY

The term Appalachian geosyncline has been applied to geosynclines of several kinds and ages, and to the Allegheny synclinorium, a structure. Sediments in the Allegheny belt were laid between the Cincinnati and Adirondack axes of flexure. Northwest was the Michigan basin, which sank progressively through the middle Paleozoic, receiving little terrigenous detritus; it is an autogeosyncline (new). To the east were the Champlain and Magog belts of the St. Lawrence orthogeosyncline, respectively a miogeosyncline and eugeosyncline in Stille's classification; Cambrian and early Ordovician sediments are carbonates in the former, argillites in the latter, separated by the Quebec axis. In times of orogeny (Taconian and Shickshockian), the Allegheny belt tilted into terrigenous detritus-bearing semilenticular depressions (deltageosynclines—new); in quieter conditions, the western border of the belt tilted northwestward into the extended Michigan basin. The Cincinnati axis was an arch only briefly, and essentially a belt of lesser depression than the adjoining autogeosyncline and deltageosynclinal belt. The Adirondack axis is parallel, extending from the Laurentides toward the termination of the Saltville thrust in Virginia, which defines the Appalachian allochthone. The northwest margin of the late Paleozoic Virginian (new) miogeosyncline extends from south-central Pennsylvania toward northern Alabama, crossing the early Paleozoic belts. Taconian thrusts developed along the Quebec axis, Appalachian along the southern Adirondack axis; the Appalachian allochthone progressively conceals the Allegheny belt southward. The autochthonous folded and minor thrust Appalachians of the south lie in the Virginian belt; the folded northern Appalachians, in the area of Allegheny deltageosynclines.

RADIOACTIVE AUREOLES AROUND SOME ORE DEPOSITS

BY N. B. KEEVIL

Mineral deposits are sometimes less, sometimes more radioactive than country rock. When the ore body is relatively high in activity, concentrations of radioactive material in the vicinity of the deposit have been observed in some instances. At

Gilman, Colorado, where a series of samples collected during a Lundberg geophysical were examined, the activity was observed to be higher near radioactive ore and to decrease in concentration away from the ore body. Some of the activity appeared to be due to diffused radon, but spectrochemical concentrations of silver, copper, lead, and zinc associated with the radioactivity suggested that much of the radioactive material was introduced during mineralization. The results suggest that sample analysis may be useful in indicating proximity to ore in some instances.

SIZE DISTRIBUTION OF SAND FROM DUNES, BEACHES, AND SOME SANDSTONES

BY W. D. KELLER

In the hope of obtaining decisive data on the size distribution of sands diagnostic of aeolian or aqueous deposition, 834 specimens were collected, screened, and their analyses plotted using the phi (Krumbein) logarithmic scale. The mechanical work has just been finished; a preliminary survey of the data indicates the following:

Samples from 29 localities on the Oregon and California coast collected along lines from the beach inland across beach-derived dunes show a mean phi quartile deviation of .22 for the beach sand but .26 for the dune sand. Beach sand is slightly better sorted (not enough to be diagnostic) than that from the dunes to which it contributes. The mean skewness value for the beach sands is negative (−.038); that for the dune sand is positive (+.029).

Slight positive skewness predominates in curves on 20 samples from Dune Park, Indiana, 55 samples from Winnemucca, Nevada, dunes, 15 samples from Pasco, Washington, dunes, and 103 samples from Moses Lake, Washington, dunes, but in 60 samples from Death Valley, 32 from Columbia River dunes, and 100 samples from the dunes west of Yuma, Arizona, slight negative skewness predominates. Direction of skewness cannot be correlated solely with the depositional agent.

Inspection of the data shows that finer dune sands are better sorted than the coarser, but a quantitative report on this as well as other relationships must wait for more detailed study.

SIERRA DEL ROSARIO, DURANGO

BY LEWIS B. KELLUM

At its northwest end Sierra del Rosario consists of six symmetrical anticlinal ridges of lower Cretaceous, rudistid-bearing limestone. This simple structure becomes very complex within a few miles to the southeast as the folding overturns to the northeast, and secondary folds develop between the primary ones. In a section across the central part of the range practically all the rocks dip to the southwest at 25° to 75°. In this part it is difficult to trace the axes of the anticlines because the turn-over of the beds is rarely preserved, and traverses along the strike are made difficult by dense underbrush, by relief, and by intense dissection of the range with high, steep-walled, transverse canyons.

The La Peña formation of Aptian age is richly fossiliferous in the southern part of the range. Beneath it are thick-bedded limestones locally rich in rudistids. In one small area on the eastern side, north of its center, sandstones of the Neocomian, exposed beneath the limestones, form foothills along the mountain front. The highest part of the ranges structurally is, therefore, along the eastern front.

Immediately west of these Neocomian outcrops a small granitic intrusion has domed the limestones. The similarity of these relationships to those previously mapped in the next parallel range to the east—*i.e.*, Sierra de Mapimí—indicates a common origin and genetic relationship.

ORIGIN OF THE QUARTZ DEPOSIT AT FAZENDA PACÚ, BRAZIL

BY PAUL F. KERR AND ALBERTO ERICHSEN

The deposits of crystal quartz now being worked at Fazenda Pacú, Minas Geraes, Brazil, provide the most important source of commercial crystals in Brazil. Crystals occur in a deeply weathered zone along the contact between the Archean and overlying Silurian sediments. Decomposition of the matrix obscures direct evidence of origin, but the quartz is believed to have been formed originally by coarse crystallization in veins. In addition to deposits formed *in situ*, clay and gravel deposits occur in which the gravels are rounded quartz crystals.

EROSIONAL ORIGIN OF SOME DESERT RANGES

BY CHARLES KEYES

The lofty Mesa de Anguila is an isolated, flat-topped mountain, rising abruptly out of the general plains surface on the Rio Grande 100 miles southeast of El Paso, Texas. It presents all the common characters of a Basin range, although not necessarily a range of that order, for it is 1000 miles from the Great Basin. The Great Basin ranges themselves are before all Desert ranges, however, whatever may be their supposititious origin.

The most noteworthy feature of the Anguila Mountain is that it is cut by a canyon, considerably more than half a mile in depth, in the bottom of which flows the Rio Grande. The river enters the canyon at the general plains level and leaves it on the other side of the mountain at the general plains level. There are no falls or rapids between. In the general regional lowering of the country round about, the river has held its own through the hard mountain rock.

The depth of the canyon is something of a measure of the magnitude of the regional denudation taking place during relatively recent geological times. In order to form its canyon, the river must have been there before the mountain. When it initiated its course over the general plains surface as the country rose in the epeirogenic upraising of the Cordilleran region, it chanced to pass over the spot where the future mountain was to develop. With the downcutting of the region the mountain also took form and constantly continued to grow higher until it reached its present elevation of 3000 feet above the plain. The soft Tertiary sands and clays round about melted away from the hard mountain rock. A Desert range graved already and entirely by differential erosion resulted.

FLOOD DEPOSITS OF ARROYO SECO, LOS ANGELES COUNTY, CALIFORNIA

BY W. C. KRUMBEIN

This study represents a continuation of earlier work in San Gabriel Canyon. Deposits left in Arroyo Seco by the flood of March 2, 1938, were mapped in the field, and samples were taken to determine how sedimentary characteristics varied with distance from source. An area of Lowe granodiorite near the headwaters of the stream afforded an opportunity for studying size and roundness of particular pebbles, free from contamination. As in San Gabriel Canyon, the flood deposits were arranged largely in log and boulder jam deposits, which formed a series of partially overlapping features along the valley. These jam deposits were found to have reverse size gradients, in that mean size of the boulders increased markedly downstream along their extent.

In general, however, neither the size nor the sphericity of pebbles in the flood deposits, collected in corresponding portions of successive log jams, showed any change along the valley; roundness, on the other hand, increased noticeably downstream. These results agree with findings in San Gabriel Canyon and suggest that size and shape respond to the dynamical conditions at the immediate site of deposition, whereas roundness is strictly a function of the distance of transport. (Geological Society project.)

DIFFERENTIATION OF SEDIMENTS DURING THE LIFE HISTORY OF A LANDMASS

BY PAUL D. KRYNINE

The tectonic and geomorphic processes which shape the successive stages of the development of a landmass also control on a broad regional scale the sediments related to each stage. Such differentiation is most easily studied in medium-grained clastics ("sandstones").

These processes operate: (1) directly by controlling both relief and topography within source area and basin of deposition; and also controlling depth and intensity of metamorphism and igneous activity which shape the material to be brought into the region of erosion; and (2) indirectly by influencing climate through topography.

The following tectonic stages and their corresponding "sandstones" seem to be well defined in the central part of the Appalachian Trough, and their counterparts appear to be also present in the Alpine and Himalayan regions:

(1) *Peneplanation (or early geosynclinal) stage:* cyclic deposition on fluctuating flat surface after much weathering, characterized by *first-cycle quartzites* and quartzose sandstones (Gatesburg).

(2) *Geosynclinal stage:* basinal deposition interrupted by local vertical buckling, and regional marginal upwarping which shifts earlier sediments to the center of the basin after low-rank metamorphism. Typical sediment: *graywackes* (normal dark gray or red). Examples: Oswego, Juniata, Chemung, Catskill, Alpine molasse, Siwalik of India.

Reworked second cycle quartzites (Tuscarora, Oriskany) and unusual tectonic arenites (Bellefonte) may be interbedded with graywackes.

(3) *Post-geosynclinal stage:* uplift (frequently by faulting) after folding and magmatic intrusion of geosyncline. Typical sediments: *arkoses* and similar first-cycle, fresh clastics from deep-seated high-rank sources (Triassic of Connecticut).

These types may be complicated locally.

PALEOGEOGRAPHIC AND TECTONIC SIGNIFICANCE OF SEDIMENTARY QUARTZITES

BY PAUL D. KRYNINE

Sedimentary orthoquartzites and highly quartzose sandstones originate either as first-cycle deposits following intense chemical weathering of source area or as second-cycle affairs through reworking of pre-existing quartzose sediments.

First-cycle quartzites generally follow prolonged and intense chemical decay in peneplaned regions (Gatesburg, Uinta). After passage through beach or dune stages deposition proceeds on flat surfaces in subaerial or subaqueous environments. Marine deposition in typically shallow seas, highly charged with dissolved silica and alkalies, results in large-scale authigenesis. In portions of such seas inaccessible to

clastic detritus cherts appear in abundance. Beside authigenic minerals first-cycle quartzites are characterized by concentration of rounded stable detrital mineral species like tourmaline and zircon, resulting in great complexity of these species: 13 varieties of tourmaline in Gatesburg, 9 in Uinta. Locally abnormal contamination from monadnocks may bring floods of angular unstable minerals. First-cycle quartzites are related to beginning or end of a geosynclinal cycle. They follow arkoses and precede graywackes.

Second-cycle quartzites are formed through reworking of pre-existing quartzose sediments. Petrographically they contain in their coarser-grade sizes fragments of older quartzites and at places much detrital chert (Tuscarora-Shawangunk, Oriskany, Weber). Authigenesis is less abundant than in first-cycle quartzites. Tectonically second-cycle quartzites are related to mature portions of the geosynclinal stage and are formed on large scale during periods of regional marginal upwarping of geosynclines which bring into the zone of erosion older quartzites with resulting shift of sediments toward the center of the geosyncline. Second-cycle quartzites are hence interbedded with graywackes.

PALEOGEOGRAPHIC AND TECTONIC SIGNIFICANCE OF GRAYWACKES

BY PAUL D. KRYNINE

Graywackes, which in the classical sense are "dirty" sandstonelike rocks containing an abundance of slate, shale quartzite, and chert fragments, are typical of the medium and late depositional stages of a geosyncline. These stages are characterized by local vertical buckling along zones of weakness in the central part of the geosyncline and by large-scale regional tilting, warping, and minor revolutions (Taconic) in the marginal parts. This brings older sediments of the early stages again into the zone of erosion, either without alteration or after subjection only to low-rank metamorphism (slates and phyllites) due to shallow burial and moderate orogenesis. After reworking, these sediments are shifted toward the center of the geosyncline. Since the central parts of the geosyncline are preserved best and the margins generally eroded, graywackes produced by reworking of mildly metamorphosed marginal deposits become the typical clastic sediment of ancient geosynclines. The term as used here is a general one covering both typical dark graywackes and red schist arenites. Within one geosynclinal cycle low-rank metamorphic material generally predominates in the earlier (older) graywackes, sedimentary material in the later.

Typical examples of early graywackes are: Oswego, Chemung graywackes, and red schist arenites of Juniata and Catskill; of late graywackes, Pennsylvanian of Appalachian region, Alpine molasse, and Siwalik of India.

Reworking of older quartzites may produce second-cycle quartzites interbedded with graywackes such as the Tuscarora and Oriskany.

SILICEOUS OÖLITES AND CHEMICAL SEDIMENTATION

BY P. D. KRYNINE, A. P. HONESS, AND W. M. MYERS

Siliceous oölites are abundant in the Upper Cambrian Gatesburg and Mines formations of Central Pennsylvania. They recur cyclically in 1- to 15-inch layers interbedded with calcareous oölites, quartzose sandstones, quartzites, dolomites, limestones, and local intraformational conglomerates.

Typical oölites are developed in perfect concentric (radial!) rings around variable cores, generally quartz grains. The primary character is evident from crushing and rehealing and from the occurrence of broken siliceous oölites as detrital fragments in intraformational conglomerates directly above the oölitic layers.

Two pene-contemporaneous generations of silica are apparently present: (1) body of oölites, deposited concentrically during free rolling period, and (2) interstitial silica between oölites after movement. This second generation silica may differ in color from the main body and forms festoons and other botryoidal excrescences protruding from the oölite.

Contact zones between siliceous and calcareous oölitic layers are characterized by spectacular "half breed" oölites formed by alternating concentric layers of silica and carbonates, proving alternating periods of deposition of these two compounds. This implies cyclic fluctuations of alternating periods of supersaturation of sea water in silica and carbonates, which agrees with less spectacular evidence provided by alternation of primary "secondary" silica and primary calcareous cements in Paleozoic quartzose sandstones.

Siliceous oölites and associated sandstones show evidence of considerable sea-bottom chemical activity as expressed in authigenesis of quartz, feldspars (both K and Na varieties), tourmaline, anatase, rutile, and carbonates.

There is no evidence of any important secondary silicification of carbonates, but on the contrary large-scale local replacement of silica by pene-contemporaneous dolomite is abundant.

PETROLOGY OF ORDOVICIAN-SILURIAN BOUNDARY IN CENTRAL PENNSYLVANIA

BY P. D. KRYNINE AND O. F. TUTTLE

Different interpretations of the boundary between the Ordovician and Silurian exist because of lack of fossil evidence. Stratigraphic units involved are:

(1) Oswego (Bald Eagle) graywacke, at places conglomeratic, a typical gray, greenish or black graywacke, erroneously described as "arkose" or "sandstone." Composition is extremely constant: around 50% very angular quartz grains; 10% clay; 3-5% feldspar (up to 10-15% near base); 40% or more (up to 80%) of rock fragments (slates, phyllites, argillites, schists); heavy minerals: idiomorphic or angular tourmaline, zircon, iron ores, very little hornblende, kyanite; some iron carbonates, much pyrite.

(2) Juniata (Queenston) red schist arenite (loosely called "red beds"), could be called colloquially a "red graywacke." This contains more shale than the Oswego. The petrography is almost identical with Oswego, excepting that rounded quartz grains begin to appear near the top, also round tourmaline and zircon, and numerous red sandstone pebbles.

(3) Tuscarora (White Medina) quartzite and its eastern facies, the Shawangunk conglomerate, are made up of 95-98% rounded quartz grains and in coarser facies of easily recognizable quartzite fragments (very little vein quartz). Rounded tourmalines in the Tuscarora can be divided into same 13 varieties characteristic of Upper Cambrian present in identical frequencies. Red tongues in Tuscarora are reworked Juniata.

The interpretation is: Oswego and Juniata are fundamentally alike, excepting that Juniata was deposited in an oxidizing environment, Oswego in a reducing one. Both are made up of reworked Lower Ordovician fine-grained sediments and low-rank

metamorphic rocks. The Tuscarora is made up of reworked quartzites, mostly Cambrian orthoquartzites. Major diastrophism occurred between Juniata and Tuscarora, minor break inside of Oswego.

BELLEFONTE SANDSTONE: EXAMPLE OF TECTONIC SEDIMENTATION

BY P. D. KRYNINE AND O. F. TUTTLE

The Bellefonte sandstone outcropping near the axis of Nittany Arch, Centre County, Pennsylvania, forms a 14-foot arenaceous layer amidst a 5000-foot series of Lower Ordovician limestones and dolomites. Petrographically it is a varying mixture of two end members—rounded pure quartz sand and subangular gravel of dolomite pebbles. Quartzitic or dolomite-arenite facies dominate locally but pass abruptly into each other. Heavy minerals are approximately 50 per cent tourmaline and 50 per cent zircon.

Dolomite pebbles can be referred to various Lower Ordovician formations. The quartz sand is directly traceable to the Upper Cambrian Gatesburg and Mines formations 3500 feet below Bellefonte. The evidence is threefold: (1) Both formations contain identical percentages of same tangible 13 varieties of rounded tourmaline; (2) Rounded tourmalines in Gatesburg have developed after deposition striking authigenic overgrowth of colorless sedimentary tourmaline ($N_e = 1.615$; $N_o = 1.630$). Rounded tourmalines in Bellefonte have identical overgrowths, but abraded and worn; (3) Upper Cambrian are characterized by siliceous oölites. Fragments of reworked siliceous oölites present in Bellefonte. Last two are veritable petrographic guide fossils.

Heterogeneity of composition, abrupt lithologic changes, and angularity of dolomite pebbles indicate simultaneous local erosion of several formations and very brief transport.

This implies a 3500-foot hiatus between Gatesburg and Bellefonte which from additional studies appears to be distributed among almost a dozen smaller unconformities.

Tectonic implication is that recurrent local vertical buckling active along Nittany Arch interrupted periodically general subsidence and brought into the zone of erosion older sediments which upon reworking formed unusual clastics along the flanks of the arch. Horizontal folding of the Appalachian Revolution followed these early Paleozoic zones of vertical buckling.

PALEOGEOGRAPHIC AND TECTONIC SIGNIFICANCE OF ARKOSES

BY PAUL D. KRYNINE

Arkose deposits are produced when a granitic (or highly feldspathic) terrane is broken up, eroded, and deposited under conditions when mechanical weathering proceeds faster than chemical decay. Relative rather than absolute figures are important. Ultra-rapid (linear or vertical) erosion proceeding through impact on steep slopes in a tropical humid climate masks and neutralizes chemical decay and produces large-scale arkose deposits quicker than relatively slow erosion in semiarid, arid, or glacial regions. So-called "deserts" of the American Southwest are quite abnormal in this respect since to a large extent they depend upon high rainfall on mountain tops and also they rework fluvial deposits inherited from pluvial Pleistocene.

A restudy of arkoses in the geologic column would assign most of them to ultra-humid climates operating on very steep (not necessarily high) relief.

Tectonically arkoses are par excellence related to granitic terranes in regions of steep youthful topography. This places them at the very end of the geosynclinal stage after magmatic intrusion, uplift, and block faulting, and before peneplanation (Triassic of Eastern United States).

The common mistake in the field of confusing arkoses (rich in feldspar) with graywackes (rich in nonfeldspathic rock fragments) is sure to lead both to petrologic and to interpretative disaster.

TRIASSIC SEDIMENTS OF CONNECTICUT

BY PAUL D. KRYNINE

The Connecticut Valley Triassic sediments form a wedge 125 miles long bordered on the east by the N.-S. "Great Fault" with displacement of 17,000-35,000 feet. The wedge is built of coalescing alluvial fans radiating westward from the fault and thinning from 16,000 to 1500 feet in 32 miles.

The stratigraphic units are: (1) Lower: New Haven arkose, up to 8500 feet, relatively coarse fluvial gray and pink arkoses, conglomerates, red feldspathic sandstones, and subordinate red siltstones and shales; (2) Middle: Meriden formation, up to 2800 feet, fine-grained lacustrine and paludal variegated and dark siltstones, shales, limestones, light feldspathic sandstones, subordinate coarse clastics, and three basaltic lava flows; (3) Upper: Portland formation, up to 4000 feet, fluvial deposit similar to New Haven.

Relative frequencies of 19 nonopaque heavy minerals divide the Triassic into seven mineral zones. Conglomerates form 10%, sandstones 64%, siltstones and shales 25%, red color is present in 52%. Near the Great Fault sediments pass into fanglomerates.

Two main groups of alluvial fans are present: Central Connecticut (indicolite and little epidote) and Southern Connecticut (no indicolite, much epidote). Almost all the sedimentary detritus is derived from a source area only 3 to 10 miles wide east of the steep, moderately high Great Fault whose recurrent rejuvenation controlled sedimentation.

Thick red clay (locally derived from a source area belonging to same climatic province as basin of deposition), huge swamps, and the flora suggest heavy precipitation (above 50 inches) and high temperature (70° to 80° F.). Fresh arkoses and fanglomerates can easily form under Tropical humid climate in regions of steep topography by linear erosion. Desiccation marks indicate alternating dry and wet seasons.

CONNATE WATERS RECOGNIZED IN UNDERGROUND CIRCULATION

BY A. C. LANE AND C. M. ALTER

Waters in which beds are laid down (connate) are soon altered by circulation. Fresh-water springs that rise from ocean bottom illustrate.

Circulation may extend miles from outcrop and hundreds of feet down, and have extended past surfaces (unconformities). Abnormal freshness or sodium ratio may indicate this or originally not marine origin.

Also diagenetic reactions with the rock occur (?). Yet while rarely will connate waters not be altered, even apart from changes due to orogenic movements or metamorphism, it is hard to get rid of them entirely. They are likely to be best preserved in synclinals, in lenses isolated in impermeable clays, and in relatively impermeable, but still porous rocks.

Tests show that fresh or paraffin-coated chunks of cores of such rocks after being washed or boiled quickly in distilled water yield signs of connate salts to later successive leachings in distilled water.

GLACIAL MAP OF NORTH AMERICA—IV: EAST-CENTRAL UNITED STATES

BY M. M. LEIGHTON, F. T. THWAITES, AND G. W. WHITE

The problems involved in the mapping of the glacial deposits of Illinois, Indiana, Michigan, and Ohio will be analyzed and discussed, as will also needed researches. As elsewhere in the country, the study and mapping of the glacial deposits have been done by a large number of workers in different areas, under different conditions, and in different stages in the progress of glacial science. Necessarily, therefore, the work of compiling, correlating, and adjusting the mapping information has brought to the foreground conflicting results. With a view to obtaining helpful discussion of the points in question, the more important problems, insofar as possible, will be set forth with illustrations.

RE-ESTABLISHMENT OF THE MISSISSIPPI RIVER AFTER THE ILLINOIAN GLACIATION

BY FRANK LEVERETT

The paper deals mainly with the effect of Illinoian glaciation on the Mississippi River on the borders of Iowa. The part of the river above Davenport probably was tributary to the Illinois River. The present westward course to Muscatine connected it with another large preglacial valley traceable down to the mouth of the Des Moines River past the head of the Lower Rapids.

The Illinoian glaciation gave the Mississippi a temporary course along its outer border, with a lake (Calvin) above the junction of the Iowa and Cedar rivers having a spillway at its south end, near Columbus Junction, that held the lake up to between 710 and 725 feet. The channel descends about 90 feet in the 75 miles to the head of the Lower Rapids.

On the withdrawal of the Illinoian ice sheet the lake opened the present lower course of the Iowa River below Columbus Junction across the Illinoian drift, forming a shallow valley 2 to 5 miles wide. Because of the rock barrier on the Lower Rapids the Mississippi valley was very slowly deepened, and there was a thin development of gumbotil on the Illinoian drift. Skunk River, like the Iowa, opened a very shallow valley 15 to 25 feet deep and about 2 miles wide, in the Illinoian drift. It has since formed an inner valley 100 feet deep and about half a mile wide.

MUDDY MOUNTAIN, NEVADA, BELT OF THRUSTING RESTUDIED

BY CHESTER R. LONGWELL

An area comprising about 140 square miles in the northern part of the Muddy Mountains, Nevada, has been restudied in detail, in an attempt to interpret complex structural features and to date the major deformation. The following principal conclusions have resulted from the study.

(1) A thrust plate of Paleozoic limestone and dolomite overrode the area from the west. Removal of the plate by erosion, except for scattered remnants, has provided in a wide belt an exceptional display of strata that were strongly deformed directly beneath the thrust.

(2) On the south the area is separated by a steep transverse fault from the main Muddy Mountain thrust mass. Evidence near the west end of the transverse fault

indicates that the thrust affecting the northern area lies structurally higher than the main thrust. The higher thrust appears to continue northward into the Mormon Mountains.

(3) Strata in the upper part of the deformed section contain fossil wood and leaves, invertebrate shells, and *Charophyta,* which agree in indicating an early Upper Cretaceous date. These beds grade upward, with local unconformities, into exceptionally coarse fan deposits that include fragments of thrust masses nearly half a mile long. The combined evidence suggests strongly that the major deformation occurred during Upper Cretaceous time. The thick sedimentary section formed near the thrust front preserves an exceptional record of the movement. (Geological Society project.)

LATE-GLACIAL UPLIFT OF NEW ENGLAND

BY RICHARD J. LOUGEE *

Results of a survey of late-glacial water levels in New England permit the drawing of an isobase map which presents some new conceptions of late-glacial history. Principal water planes furnishing data are those of the Dana Marine Stage of southern New England, Lakes Hitchcock and Upham in the Connecticut Valley, the marine submergence north of Boston, and Glacial Lake Champlain.

Three periods of regional uplift alternating with periods of prolonged stability are recognized. The first uplift antedates the earliest known land movement in the Great Lakes area and occurred when the ice front stood at Plainville and Middletown, Connecticut, and Plymouth, Massachusetts. The ensuing period of stability lasted at least 4000 years until Littleton, New Hampshire, was uncovered, when the second movement began. The second and third uplifts are the Whittlesey and Algonquin movements of Great Lakes history. The third movement started after the ice front had retreated from New England.

Each uplift was greatest toward the north and each affected a definite area bounded on the south by a hinge line. Activity migrated northward with successive uplifts, as in the Great Lakes area. Tilt rates in feet per mile vary from 2.2 in New Jersey and 3.5 in central Massachusetts, where one uplift alone is recorded, to 6 in southern Connecticut and 9 in central New Hampshire where two uplifts are compounded. The total measurable uplift at the Vermont-Canada border is 1800 feet. On the map each uplift is ne essarily distinguished by its own set of isobases.

GLACIAL MAP OF NORTH AMERICA—V: NORTHEASTERN UNITED STATES

BY PAUL MAC CLINTOCK

In New England detailed mapping of the Wisconsin moraines in eastern Massachusetts by Mather, R. P. Goldthwait, and Thiesmeyer has made noteworthy progress. Whether or not there are two drift sheets as suggested by Currier and Jahns is still under investigation. J. W. Goldthwait and associates report evidence of only one drift.

In Pennsylvania and New York the drift sheet on the west side of the Salamanca re-entrant is younger than that on the east side and extends eastward as a recognizable drift sheet at least as far as Binghamton, New York, beyond which it was not traced. It was also traced westward and correlated with the Cary (Valparaiso) moraine at the Ohio-Pennsylvania line. This correlation means that the older

* Introduced by George Otis Smith.

Wisconsin drift of the east limb of the re-entrant, and extending at least into east-central Pennsylvania, is of Tazewell age. It also strongly suggests that the next younger drift which makes the Valley Heads moraine of New York is of Mankato age.

Irregularity in the lithology of the Wisconsin drift sheets near the re-entrant, which had caused confusion in the past, has been caused by the Wisconsin ice overriding and locally incorporating material from patches of much-eroded Illinoian drift. The normal lithology of the drift on the west side of the re-entrant is high in lime and igneous erratics, whereas that on the east side is low in these constituents. In an exposure at Otto, New York, is seen: (1) weathered Illinoian till; (2) Sangamon peat; (3) low-lime drift; (4) high-lime drift.

STRATIGRAPHY OF THE TEJON FORMATION IN ITS TYPE AREA, KERN COUNTY, CALIFORNIA

BY JAY GLENN MARKS *

The type area of the Tejon formation (Eocene) is on the north slope of the Tehachapi Mountains at the extreme south end of the San Joaquin Valley, between Pastoria Creek on the east and Tecuya Creek on the west. The Tejon marine sediments form a wedge of steeply dipping strata 410 feet thick at Pastoria Creek and 4380 feet in Reed Canyon, ¼ mile east of Tecuya Creek. The four conformable members of the Tejon formation here named as new are as follows:

TECUYA FORMATION		Continental deposits of Oligo-Miocene age
		unconformity
TEJON FORMATION	Reed Canyon silt member	Type locality: Reed Canyon. 160 feet of dark-gray silt and clay shale. *Ectinochilus elongatus, Turritella schencki, Discocyclina* sp. nov., *Uvigerina* cf. *cocoaensis.*
	Metralla sandstone member	Type locality: Reed Canyon. 1300 feet of concretionary gray sandstone. *Cimonia* sp., *Pteria pellucida, Nonionella* cf. *frankei, Plectofrondicularia cookei.*
	Liveoak member	Type locality: Liveoak Canyon; stratigraphic relations established in Grapevine Canyon. 1970 feet of sandstones and silts. *Ficopsis hornii, Turritella buwaldana, T. neopleura, T. uvasana, Whitneyella sinuata.*
	Uvas conglomerate member	Type locality: Grapevine Canyon. 110 feet of fossiliferous conglomerate. *Tubulostium tejonensis, Actinocyclina* cf. *aster, Discocyclina* sp.
		unconformity
BASEMENT COMPLEX		Granitic rocks

Tertiary dacite agglomerate and a flow of andesite overlie the Tecuya beds in Reed and Grapevine canyons. In Liveoak Canyon and farther east the andesite flow alone is present. A coarse Cenozoic fanglomerate unconformably overlies the volcanics.

AREAL GEOLOGY NEAR TECOPA, CALIFORNIA

BY JOHN F. MASON †

The areal geology of an area that may be the root zone of the Amargosa thrust and other sheets described in the Death Valley (Virgin Spring) area by Noble is

* Introduced by Hubert G. Schenck.
† Introduced by W. T. Thom.

presented. The stratigraphy of the Algonkian and Cambrian strata in the Tecopa area was studied by Hazzard assisted by the writer. The present map is an attempt to utilize the published stratigraphic units of Hazzard and Hewitt as cartographic units, in parts of the Shoshone and Tecopa quadrangles, southeasternmost Inyo County, California. The Cambrian and Algonkian strata, amounting to more than 16,000 feet, are involved in structural complexity suggesting westward thrust faulting on a large scale. The sedimentary section apparently has been skidded off the rigid Archean basement, and similar skidding of younger over older beds occurs higher in the section at two or three preferred horizons. The direction of movement in nearly all cases seems to be west, a fact not yet harmonized with directions of movement reported in neighboring areas. High-angle faults, including those of the Basin Range faulting, are mapped.

SPECIFIC DATA ON THE SO-CALLED "READING OVERTHRUST"

BY BENJAMIN L. MILLER

In three critical locations deep drilling continued in crystalline rocks from 600 to 900 feet below the point where Paleozoic limestones should have been encountered according to the "Reading Overthrust" hypothesis. Several areas designated as "windows" of Elbrook limestone of the "autochthonous block" contain no limestone and are only lowered erosion surfaces in the crystalline rocks.

Field evidence reveals several errors in the published maps. Revised mapping indicates that synclines and downdropped blocks explain the structure better than extensive overthrusting.

The designation of Elbrook limestone in areas of no exposures gives the appearance of an overthrust block. There is generally much better reason for mapping Tomstown limestone in such places, inasmuch as the shaly character of this formation furnishes few existing outcrops. This would be the normal succession.

Extensive geophysical data with the gravimeter have added much information to the pendulum gravity determinations of the U. S. Coast and Geodetic Survey. These definitely do not furnish evidence of the "overthrust."

The position of the jasperoid is determined by several exposures. It appears far up on the slope of South Mountain with the Hardyston sandstone dipping beneath and not where the sole of the overthrust(?) would be. A varied series of additional observances render the overthrusting of a great block constituting the present Reading Hills highly improbable if not impossible.

If the structural pattern of the Stose-Jonas maps suggest an eroded overthrust block, it is largely due to interpretative mapping.

Specific evidence, if there is any, in support of the "Reading Overthrust," is awaited.

DEPTH OF ROCK DECAY IN THE SOUTHERN APPALACHIANS

BY BERLEN C. MONEYMAKER*

That rock decay in the southern Appalachian Mountains has progressed to "considerable depths" below the surface is a matter of common knowledge. In order to determine, quantitatively, the downward extent of complete and partial rock decay, a study was made of deep excavations, tunnels, and deep bore holes in the mountains of eastern Tennessee and western North Carolina, especially in the

*Introduced by Edwin C. Eckel.

basins of the Hiwassee and Little Tennessee rivers. It was found that in such siliceous rocks as gneisses, schists, slates, and quartzites the depth of decay is to be measured in hundreds of feet. In ridges and peaks standing 300 to 600 feet above the river, rock may be nearly completely decayed to depths in excess of 250 feet. Slight decay, marked by rusty joints and decayed ferromagnesian minerals, extends to depths as great as 450 feet below the surface. At several localities where the Hiwassee and Little Tennessee rivers are flowing on siliceous bedrock, rusty joints and zones of decayed rock are present to depths of nearly 100 feet below the stream bed.

GOLD MINERALIZATION IN MINOR IGNEOUS INTRUSIONS

BY W. W. MOORHOUSE*

The association of gold mineralization with or in porphyry dikes and bodies is known in many parts of the Canadian shield. This relationship has frequently been considered to be purely structural or genetic only in the sense of derivation from the same magmatic source. Evidence of a much more intimate connection is given from an occurrence of auriferous pyrite as disseminations and in quartz-carbonate veins in albitite porphyry in Bryce township, Ontario. The porphyry is in part a normal dike, in part a replacement of associated schists. Stringers extending into the schists are enclosed by a zone of albitization which resembles the porphyry itself. This, with other examples from the same area, is believed to indicate that replacement and intrusion by albitic material were accompanied by the gold-pyrite mineralization. Comparisons are given with other gold deposits associated with porphyry and albitite dikes and bodies in Canada.

Auriferous quartz-sulphide mineralization which has been discovered in small altered dioritic bodies in relationships of the veins to these intrusives suggests a rather close genetic connection. Reference is made to comparable gold deposits described in the literature.

SOLUBILITY OF SOLIDS IN "GASES" OR "VAPORS"

BY GEORGE W. MOREY AND EARL INGERSON

The transport in significant quantity of solid material by means of a gas or vapor at high temperature and pressure is dependent on solubility of the solid in the vapor. This means that in unit volume of the vapor the content of solid is greater than corresponds to its own vapor pressure at the temperature and total pressure under consideration. The writers have found transport and deposition of corundum, rutile, sillimanite, quartz, and amorphous silica by water at temperatures from 500° to 1000° and at pressures from 3000 to 15,000 pounds. These experiments and products will be described.

The consideration of problems of solubility of solids in vapor requires rigid definition of the terms "gas," "vapor," and "fluid" as applied to phases coexisting in several-component systems under conditions in which definitions which are logical and complete for a one-component system no longer are applicable. Definitions of "gas" and "vapor" are proposed.

The further discussion of the problem of the solubility of nonvolatile solids in a vapor will be made with the aid of diagrams illustrating the variation of temperature, pressure, and composition in binary systems in which different types of critical end-points are assumed.

* Introduced by E. S. Moore.

GEOLOGIC RECORD AND HELIUM TIME SCALE

BY FREDERICK K. MORRIS

A test of the time scales which physicists and chemists propose is the question, How do the known geological events fit into the proposed time scale? Geological studies independent of age determinations tend to show where longer time is demanded by the magnitude of the history which these studies reveal, and the geologist looks to the chemist-physicist for evidence tending to increase the time scale at the places where the known record of earth history requires greater time than was formerly assigned. Our growing knowledge demands a longer Pleistocene period; a long interval between Cretaceous and Paleocene; a long interval between Permian and Triassic; and an especially long pre-Cambrian interval. The "proposed helium time scale" reported by Hurley and Goodman offers part of the time which geologic history demands, especially a longer pre-Cambrian time than has been afforded by earlier reckonings. In presenting the paper, consideration will be given to the reasons for welcoming these changes in the geological time scale.

ANALYSES FOR AGE BY LEAD RATIOS

BY O. B. MUENCH*

Analyses (1) and (2) of early tertiary pitchblende from Gilpin County, Colorado, (3) early pre-Cambrian monazite from the Huron claim near Winnipeg, Manitoba, (4) monazite from near Las Vegas, New Mexico, and (5) euxenite from Colorado are reported with lead age ratios as follows:

(1) 0.0146: (2) 0.0167: (3) 0.257: (4) 0.105: (5) 0.059

The proportions of isotopes in the lead of the first four, which were executed with the help of a grant from the Elizabeth Thompson Fund, have been determined by A. O. Nier. (Geological Society project.)

GLACIAL MAP OF NORTH AMERICA—VI: CANADA

BY D. A. NICHOLS †

The Glacial Map of North America being compiled at the Bureau of Geology and Topography, Ottawa, Canada, under the supervision of a National Research Council committee, is being constructed on a scale of 40 miles to 1 inch, on a base projection calculated on Lambert's Conformal Conic Projection formula. The sheets consist of 11 units which will be combined and published on a scale of 60 miles to 1 inch or fewer sheets.

The features shown on the map are: existing glaciers, areas covered by drift, outwash in nonglaciated areas, glacial and extraglacial lakes, occurrences of interglacial features, glacial-marine deposits, areas in which varved sediments occur, striae, esker and drumlin patterns, and boulder trains.

Nearly all the Canadian data are laid down on work sheets ready for reduction and transfer to the base map. The compilation of the Arctic regions north of latitude 60° has been transferred. The area east of longitude 95° has been nearly completed and transferred to the base, and the United States data will be added soon. Data for Alaska, Iceland, and Greenland are ready for conversion to base-map scale.

* Introduced by A. C. Lane.
† Introduced by R. F. Flint.

Many significant features are appearing as compilation proceeds. The great esker patterns within the areas west of Hudson Bay, and south and east of James Bay, and belts of end moraine in central United States are startlingly emphasized. The extent of marine submergence is also strikingly shown.

TREE RINGS IN LAVA

BY ROBERT L. NICHOLS*

More than a score of basaltic flows were very recently extruded from a fissure several miles long near Bend, Oregon.

Several thousand lava trees and tree molds have been found on these flows, indicating that the flows ran into a dense forest. The molds of trunks, branches, roots, and root mats are common. The molds of the trunks are as much as 50 feet long and 4 feet in diameter, and a root mat was found which was nearly 10 feet across. Many of these trees were growing in loose pumice, some of which, having been melted and fused together by the heat of the basalt or the burning log, was found in a root-mat mold. Large rock fragments, around which the roots of these trees grew, have also been found in root-mat molds.

The molds are often empty, although many are partly filled with secondary lava. This lava forms stalactites, stalagmites, columns, miniature flows, and shelves. Some of it ran into and onto charcoal logs, for both charcoal and coke have been found on its surface as well as completely surrounded by it. Tree-ring impressions are common in this secondary lava, and specimens with more than 150 tree-ring impressions have been found.

The burning logs probably produced some of this secondary lava, although much of it may represent lava from the main body of the flow which ran into the molds through cracks in the solid shell of lava which formed around the logs.

CENOZOIC GEOLOGIC HISTORY OF THE BEARPAW MOUNTAINS, MONTANA

BY WILLIAM T. PECORA AND BERNARD FISHER †

The Bearpaw Mountains, north-central Montana, occupy about 800 square miles, about half of which is underlain by volcanic rocks and the remainder by intrusive and sedimentary rocks. All the igneous rocks are lower Tertiary, and the sedimentary rocks are principally upper Cretaceous and lower Tertiary.

Between the Paleocene Fort Union formation and a volcanic formation of probable Eocene age are beds of cemented pebbles and cobbles, of Belt origin, lithologically similar to Oligocene Cypress Hills gravels in Saskatchewan. These beds may be either an upper member of the Fort Union formation or a new Eocene formation related to the Eocene conglomerate of southern Saskatchewan.

At least three igneous stages occurred, and each was probably followed by faulting and erosion. Monzonite porphyry may have been the first of the igneous rocks, and andesitic and latitic flows and breccias were erupted on a surface of deformed sedimentary rocks.

Later igneous activity resulted in at least 15 stocks, many sills, a few laccoliths, and many hundred dikes. Shonkinite and monzonite are the principal rock varieties of the group.

* Introduced by Kirk Bryan.
† Introduced by E. S. Larsen.

Phonolitic lavas were extruded through fissures upon a surface of deformed older rocks. Latite flows were finally extruded but were relatively insignificant in volume.

An erosion surface was developed after the last eruptions and was almost completely dissected to form a surface which, on the western border of the mountains, grades from pediments to the high plains. This pediment surface was dissected before southeasterly advance of continental ice.

ARCHEAN-HURONIAN UNCONFORMITY ON THE MENOMINEE IRON RANGE, MICHIGAN

BY F. J. PETTIJOHN AND F. A. HILDEBRAND

The pre-Lower Huronian age of the granite and granite gneiss complex northeast of the Menominee iron range is reaffirmed by discovery of a hitherto undescribed exposure of basal conglomerate near Fern Creek in Dickinson County, Michigan. The conglomerate, clearly exposed in unfaulted contact with reddish granite gneiss and pegmatite, contains large subrounded boulders derived from the subjacent pre-Huronian and truncates, at an angle of 30° or more, the foliation of these basement rocks. The conglomerate lies between the granite gneiss and the Sturgeon quartzite.

The Fern Creek conglomerate, together with the conglomerates along Pine Creek, Black Creek, and at the falls of the Sturgeon River, all earlier described by Bayley, leave no room for doubt of the pre-Lower Huronian position of the granite and related rocks.

SHAPE AND ROUNDNESS OF LAKE ERIE BEACH SANDS

BY F. J. PETTIJOHN AND A. C. LUNDAHL

Seven samples of beach sand, collected at 1-mile intervals from Cedar Point spit, Sandusky Bay, Lake Erie, were sieved into half-Wentworth grades from .701-.088 mm., treated with hydrochloric acid, and split into "lights" and "heavies" by means of acetylene tetrabromide (S.G. 2.96). The "lights," mainly quartz and feldspar, were mounted in piperine on 42 glass slides. Images of the "lights" from each sieve separate were projected. The roundness (Wadell) was estimated by visual comparison with standard chart (Krumbein). The sphericity was measured by the Riley method.

The larger particles were found to be better rounded and to have higher sphericity than smaller grains of the same sample. The grains with highest sphericity also had the highest roundness in each sample. The roundness of all sizes showed a definite decrease in the direction of transport. Sphericity showed no significant decrease. The thickness, however, of the grains of the same grade sizes in each sample shows a decrease in the direction of sand movement and suggests a sphericity decline not observable from data obtained by projection method alone.

The decrease in roundness and sphericity suggests sorting by the littoral currents, the flatter (less spherical) grains tending to outrun equidimensional particles. Because the highly spherical particles are better rounded and the less spherical least rounded, this sphericity decline carries with it a corresponding decrease in roundness.

SETTLING OF HEAVY MINERALS IN A GRANODIORITE DIKE AT BRADFORD, RHODE ISLAND

BY ALONZO QUINN

A granodiorite dike at Bradford, Rhode Island, has a thickness of 65 feet, an east-west strike, and a dip of 28° south. Heavy-mineral separation of samples from

different parts of the dike indicate that the proportion of heavy minerals increases systematically toward the base of the dike. This is shown also by thin-section studies of specimens from different parts of the dike and by studies of a dark zone at the base of the dike.

The systematic increase of heavy minerals toward the base seems to be due to crystal settling for several reasons: (1) The minerals which are concentrated toward the base crystallized early in the solidification of the rock, (2) these minerals were considerably heavier than the granodiorite magma, (3) they are distributed through the body of the rock and are not concentrated along permeable zones as they would be if deposited by later hydrothermal solutions, and (4) the heavy minerals are especially concentrated in a dark zone along the base and appear to fill depressions in the slightly irregular floor.

The settling appears to have occurred when the magma was moving upward along the dike, as is indicated by the fact that the zones of equal proportions of heavy minerals are almost parallel to the base instead of horizontal. The small size of the settled grains, with zircon crystals as small as 0.10 by 0.03 millimeter, indicates a low viscosity of the magma.

WELLINGTON FORMATION IN OKLAHOMA

BY GILBERT O. RAASCH*

The Permian Wellington division in Oklahoma is limited to the north-central section of the State; southward it passes into the Stillwater redbed complex. Basal and summit boundaries contact the marine Herington limestone and the Garber redbed complex, respectively. The total thickness of 820 feet of strata is subdivided as follows: basal sequence, 18 feet; anhydrite sequence, 190 feet; Otoe (redbed) member, 115 feet; Midco (lacustrine) member, 255 feet; Billings member, 52 feet; Antelope Flats member, 195 feet. The upper 372 feet is continuously exposed at the surface and includes many conspicuous key beds. Cyclic deposition is recognized in the Midco lake beds, and their possible relation to the Wellington salt deposits is discussed. The paleontologic and mineralogic data, published and unpublished, are summarized.

Local details are especially stressed in connection with the Midco member, which is of particular interest because of the recent discovery of a rich insect and crustacean fauna there. The insect fauna is in the hands of F. M. Carpenter, the Crustacea (Estheriae excepted), of Percy Raymond. A detailed restoration of Midco environments is attempted primarily to give background for the remarkable faunal assemblage.

CAMBRIAN FOSSILS OF THE GRAND CANYON

BY CHARLES E. RESSER

The Middle Cambrian Tapeats, Bright Angel, and Muav formations constitute the Grand Canyon sequence, except that a Lower Cambrian stratum enters the section below Diamond Creek. No fossils are known from the basal Tapeats sandstone. Both the peculiar quartzitic lithology and the poorly preserved fossils indicate close relationship of the Lower Cambrian beds with formations in the Death Valley region.

The faunal assemblages of the Bright Angel formation vary considerably, depending on the lithology. In the coarse sandstones linguloid brachiopods, phyllopod crustaceans, and several trilobites are fairly abundant locally. In the soft shales and

* Introduced by F. M. Carpenter.

in certain limestone layers there are other brachiopods and many trilobites, besides fine examples of cystids. Strict zoning of these fossils is not yet possible. Characteristic trilobite genera present are *Prozacanthoides, Anoria, Alokistocare, Albertella, Clavaspidella, Glossopleura, Kootenia, Zacanthoides, Ehmaniella,* and *Pachyaspis,* all of which are indicative of an early Middle Cambrian age.

Fewer fossils are found in the prevailingly dolomitic Muav formation. *Kootenia* seems to be the most common trilobite, and other characteristic genera are *Glossopleura* and *Elrathiella* or *Parehmania.* In the upper layers *Solenopleurella* is common. Thus it is clear that the entire Cambrian faunal assemblage, and the rocks containing them, represents only a part of the Lower Cambrian and the lower third of the Middle Cambrian.

This paleontology is to be printed as a companion paper of Edwin D. McKee's stratigraphic studies.

BURIED STAGNANT ICE AS A NORMAL PRODUCT OF A PROGRESSIVELY RETREATING GLACIER IN HILLY REGIONS

BY JOHN L. RICH

The thesis is presented that tongues of ice of a wasting glacier in the valleys of a hilly region are limited in their down-melting to the level of the top of the outwash valley trains emanating from them. Any tendency for melting to proceed below this level would be checked immediately by gravel being washed into the depressions and blanketing the underlying ice against further melting.

Thus, as the glacier retreats, a layer of ice in the valley bottoms is blanketed by gravel and sand and preserved for relatively long periods. Before retreat has progressed very far it becomes easier for the live ice behind to shear across and move up over the buried ice mass than to push it forward. Thus the buried ice becomes detached and stagnant. Its final melting out, perhaps after thousands of years, and after the ice front has retreated from the vicinity, leaves the familiar phenomena of marginal kame terraces, eskers, "crevasse fillings", ice-contact slopes, and pitted plains such as have been commonly interpreted as indicating general stagnation and down-wasting of the ice margin.

It appears that these phenomena are products of the normal retreat of a wasting ice front wherever valleys are present to localize ice tongues and valley trains. Herein lies the possibility of reconciling the evidences of the presence of stagnant ice emphasized by students of New England glacial geology with the concept of progressive but not steady retreat which has arisen from studies in other regions.

MULTIPLE GLACIATION OF THE WIND RIVER MOUNTAINS, WYOMING

BY GERALD M. RICHMOND*

Blackwelder differentiated three stages of glaciation in northwestern Wyoming—Buffalo, Bull Lake, and Pinedale—on the basis of primary constitution, degree of preservation, and relative topographic position of their depositional and erosional features. These criteria, together with his correlation of glacial stages with stream cycles, are reviewed as essentially accurate.

Mapping of the glacial features reveals that during each stage an ice cap, produced by the integration of large catchment areas, covered the interior of the range. Buffalo ice was the earliest and the most widespread. Its outlines can only be

* Introduced by Richard Foster Flint.

inferred from patches of till lacking topographic expression. During Bull Lake time long ice tongues from the cap extended northeast to the Wind River, damming it at three points. Glaciers accumulating in the Absaroka Range to the north advanced down the Wind and Dunoir rivers to their junction, but failed to reach the main mass. To the west cap ice spread across the upland surface, converged down marginal canyons, and coalesced with valley glaciers of the Gros Ventre Range in a great piedmont lobe. This extended from Union Pass 32 miles south into the Green River Basin and at three localities overflowed the low divide to the northwest into Snake River drainage.

Pinedale ice developed the smallest cap and remained within the canyons. In general there are two distinct terminals, enclosing paired lakes. No consistent evidence for more than two was found. At present, over 50 glaciers are actively contracting behind small moraines.

SIZE OF SAND AS MEASURED BY SIEVING AND MICRO-PROJECTION

BY GORDON RITTENHOUSE*

Sand from the Rio Grande channel near Albuquerque, New Mexico, was sized with new sieves having a $\sqrt{2}$ ratio between openings. In each of seven sieve separates, the intermediate diameter of 275 to 646 randomly selected grains was then measured by micro-projection methods.

The intermediate diameter of 30-50 per cent of the grains was larger than the rated aperture of the finest sieve through which they had passed. Less than 2 per cent of the grains had intermediate diameters smaller than the rated aperture of the sieves on which they were retained. The distribution of intermediate diameters in each sieve separate plots on logarithmic probability paper as a straight line whose slope depends on the effective size of sieve aperture in both limiting sieves. If the effective size of sieve aperture is defined as the size at which the weight of coarser grains passing the sieve is equal to the weight of finer grains retained, the effective openings of the 0.061, 0.088, 0.124, 0.175, 0.250, and 0.351 millimeter sieves are, respectively, 0.077, 0.106, 0.148, 0.211, 0.299, and 0.419 millimeters for this sand.

Effective openings are larger than rated openings mainly because (1) Oversize holes are more important than undersize holes in determining the size of grains that will pass, and (2) most sand grains are somewhat flattened and pass diagonally through the sieve openings. The effective size of sieves will vary for sands of different shape and for minerals of different shape in the same sand.

GEOLOGY OF SIERRA DE TLAHUALILO, DURANGO

BY W. I. ROBINSON AND L. B. KELLUM

The Sierra de Tlahualilo, located on the boundary line between the States of Durango and Coahuila, Mexico, is a deeply dissected remnant of a plateaulike upland. It is composed chiefly of Lower Cretaceous strata belonging to the Cuchillo and Aurora formations. Paleozoic rocks are exposed beneath the Cretaceous along one canyon near the center of the range. At several localities around the margins and extending over the top near the north end are highly fossiliferous marls and platy limestones of the Indidura formation of late Lower and early Upper Cretaceous age.

Folding in the Cretaceous rocks is comparatively simple, but a number of distinct

* Introduced by Elden M. Thorp.

structural features are developed. The writers have recognized 10 areas characterized by separate structural units. Some of these have been mapped in considerable detail, and others by rapid reconnaissance.

The Sierra de Tlahualilo is located in the area where the Coahuila Peninsula existed as a positive element throughout Mesozoic time. The structure and stratigraphy of the Cretaceous strata in this range reflect the presence of this tectonic element.

EVOLUTION OF THE AMPHIBIA

BY A. S. ROMER

A general account is given of the older amphibian groups based on recent and current work.

Most Paleozoic forms appear to fall clearly into one of two categories: (1) Labyrinthodontia or (2) Lepospondyli. The former had a complex evolutionary history, but Watson's grouping of them into embolomerous, rhachitomous, and stereospondylous structural stages is still valid. The labyrinthodonts are ancestral to both reptiles and frogs. The "Phyllospondyli" (branchiosaurs) are not a taxonomic group but a heterogeneous assemblage of small labyrinthodonts, mainly larval forms. The lepospondyls are divisible into Nectridia, Aistopoda, and Microsauria, with which last are to be included Watson's Adelospondyli. Modern salamanders and the Apoda appear to have arisen from the microsaurs.

LOWER MISSISSIPPI VALLEY LOESS

BY RICHARD JOEL RUSSELL

Loess in the Lower Mississippi Valley, south of the Ohio River, is the product of leaching and alteration of Pleistocene flood-plain silts and clays. The original deposits were essentially identical with the finer materials accumulating today on active flood plains. Loess-covered Pleistocene terraces retain stream patterns precisely similar to those on active flood plains. Transition at depth into coarser materials characterizes both loessial and active flood-plain deposits. Shells identical with those in the loess occur in active flood-plain accumulations. Transition from silt or clay to loess depends chiefly on exposure, drainage, and leaching. The best-developed loess occurs on bluffs. Loessial characteristics disappear with increasing distance from bluff exposures. Many of the characteristics of loess and several peculiarities with regard to its thickness and distribution are associated with its mobility on slopes. No shred of evidence supports the thesis of eolian origin. Field observations on loess in the Rhine Valley, southern Germany, Limberg, southern France, the Vienna Basin, Armenia, and various parts of the United States confirm all conclusions reached in detailed studies in the Lower Mississippi Valley, and a careful consideration of literature concerning other loessial regions casts considerable doubt upon the validity of the eolian hypothesis as applied to other regions.

GEOLOGY OF THE CEDAR HILLS, UTAH

BY STUART L. SCHOFF*

The Cedar Hills occupy an area of about 320 square miles in central Utah between the northern end of the Wasatch Plateau and the southern end of the Wasatch Mountains, in the boundary zone between the Colorado Plateaus and the Great

*Introduced by Edmund M. Spieker.

Basin. The oldest exposed rocks are of Carboniferous age, but most of the area is underlain by Upper Cretaceous and Tertiary continental sediments many thousands of feet thick. The Indianola group alone is about 15,000 feet thick. It consists principally of coarse conglomerates and sandstones indicative of near-by orogeny but also contains a tongue of fossiliferous marine sandstones that show that it is of Colorado age. This group is overlain unconformably by a thick series of fluviatile and lacustrine deposits ranging from Montana to Eocene in age (Price River, North Horn, Flagstaff, Wasatch, and Green River formations), which in turn are overlain unconformably by pyroclastic rocks of probably late Tertiary age. The area was subjected to compressive orogenic disturbances in middle Cretaceous, upper Cretaceous (Montana), and probably middle Tertiary time, and to the normal faulting of the Basin-Range disturbance in late Tertiary time.

CORRELATION AND METAMORPHISM OF THE THOMSON FORMATION, MINNESOTA

BY GEORGE M. SCHWARTZ

The Thomson formation consists of a thick series of slates, graywacke-slates, and graywackes which are exposed over a large area southwest of Duluth. The formation has had several suggested correlations but in recent years has usually been considered the equivalent of the Animikie-Virginia slate of the Mesabi range. Detailed work in the past 3 years suggests that this correlation is untenable and that the formation is pre-Algoman in age. A detailed statement of the evidence bearing on the problem is given, and the progressive metamorphism of the formation toward the south is described.

The revised correlation suggests the possibility of the occurrence of upturned Biwabik iron formation in the region north of Cloquet where no outcrops occur for a distance of 50 miles to the Mesabi range.

The data likewise throw some doubt on the correlations which have been proposed for the Cuyuna range which lies about due west of the southern exposures of the main Thomson area.

WOLF CREEK GLACIER SYSTEM, ST. ELIAS RANGE, YUKON TERRITORY

BY ROBERT P. SHARP

The Wolf Creek area contains an eastward-draining trunk glacier, 25 miles long, and at least 20 smaller tributary or disconnected ice streams constituting one of the major glacier systems on the interior side of the St. Elias Range.

A former marked advance of these glaciers is tentatively correlated with similar activity of Alaskan coastal glaciers 1 to 2 centuries ago. Retreat and stagnation have since been dominant, interrupted only by minor advances, one of which is now in progress. The lower 10 miles of the trunk glacier is stagnant, but comparative observations and photographs show an increase in size and activity of the upper part during the last 6 years (1935-1941). Ice streams in high tributary valleys are advancing vigorously, while those in lower tributaries are retreating in normal fashion. The present behavior of these glaciers could easily be caused by a minor climatic change.

The stagnant ice is distinguished by a heavy cover of ablation moraine and a chaotic surficial topography produced by running water, melting, and mass movements. Low gradient and overdeepening of the valley floor combine with insufficient nourishment to cause stagnation.

Wisconsin moraines are well displayed on the tributaries of lower Wolf Creek and duplicate in appearance and comparative position the Iowan-Wisconsin and later Wisconsin moraines in mountains of western United States. Faint traces of a third Wisconsin or post-Wisconsin advance have also been observed.

RELATION OF SOIL CREEP TO EARTHFLOW IN EASTERN OHIO

BY C. F. STEWART SHARPE AND EARL F. DOSCH*

Studies of soil movements on agricultural lands in eastern Ohio reveal that the widespread slow process of soil creep prepares the way for localized and much faster earthflow. The same relationship extends to other nonglaciated parts of the Appalachian Plateau underlain by numerous coals, clays, and shales of Pennsylvanian and Permian age.

On a typical hill slope in the Plateau only the most massive beds of rock are exposed; the position of thinner or less competent beds is obscured by a mantle of soil and rock debris. Road cuts and deep auger borings show that approximately horizontal beds of coal, clay, and shale, instead of outcropping, become thinner several feet below the surface of the ground and bend down slope. Many of these can be traced downhill in attenuated form for as much as 200 feet. A layer of clay or shale thus drawn out approximately parallel to the slope interferes with downward percolation of surface water and of ground water moving laterally above the undisturbed clay stratum. Flow of ground water down the hillside is concentrated in sags or flutings in the impervious layer.

During the following prolonged precipitation or snow melt, soil material overlying the more or less impervious blanket of creeping clay locally becomes saturated. Where slopes are moderate or steep, and especially above sags in the impervious layer, earthflows may result.

Most earthflows disrupt the impervious layer and so tend to preclude recurrence of major movement.

SUBMARINE RELIEF OF THE GULF OF CALIFORNIA

BY FRANCIS P. SHEPARD

The 1940 expedition of the E. W. Scripps to the Gulf of California added approximately 25,000 echo soundings to the 5000 of the 1939 expedition. These have allowed construction of comparatively accurate submarine contour maps, which indicate that the Gulf has been downfaulted irregularly. Narrow steep-walled deeps cut the central floor of the Gulf somewhat en echelon and striking to the west of the general north-northwest trend of the Gulf. Well-developed terraces on both sides of these deeps are interpreted as due to step faults. The islands of the west side of the Gulf are bounded by steep submarine escarpments due to recent faulting. To the north a row of islands is separated from the mainland by a deep, comparable in dimensions with Death Valley, but partly V-shaped. Recent faulting has not been so evident on the east side, but the shelves are narrow, and the close proximity of the 30-fathom line to the shore suggests a slight recent submergence.

Typical submarine canyons were found around the end of Lower California and in one place on the east side of the Gulf, but not in the upper and middle Gulf. Features which might easily be confused with canyons were discovered here and also along the west side of Lower California and off Guadaloupe Island. Investigation

* Introduced by D. W. Johnson.

indicates a diastrophic or volcanic origin. On the other hand the large canyon which extends out from the granite shores of San Lucas Bay and winds down the deep outer slope to at least 1200 fathoms is as similar to river valleys as are the canyons off the California coast. (Geological Society project.)

HYPOTHETICAL SUBMARINE VALLEYS

BY FRANCIS P. SHEPARD

Recent lectures and articles about submarine valleys (canyons) refer to the numerous small valleys said to be cut into muddy slopes off eastern United States. The impression has been given that an explanation accountable for such features will explain the enigma of the submarine canyons. Few would deny that such gullies might result from one or several of the submarine processes given so much recent prominence. However, reference to these gullies is of questionable merit because:

(1) The existence of the gullies, shown by the contours on the published east coast charts, is not proven. Six other contourers using the same soundings failed to reproduce the bulk of the gullies, and the limits of sounding errors in deep water leave the existence of many others in doubt.

(2) Almost all the best known submarine valleys have true canyon proportions and are decidedly comparable to the large canyons of high land escarpments or of mountain ranges.

(3) The suggestion that the valleys are cut in wave-built mud banks does not fit the facts. Most of the investigated canyons have been shown to be cut into rock formations ranging from Jurassic to Pliocene.

(4) Examination of charts from various parts of the world shows that the typical submarine canyon is more analogous to the rocky gorges off the California coast than to the more frequently alluded to valleys off the east coast. Therefore, if a subaerial origin is admitted for the well-known California submarine canyons, it should be inferred for the others.

PERIGLACIAL FEATURES IN THE DRIFTLESS AREA OF SOUTHERN WISCONSIN

BY H. T. U. SMITH

At several places in the Driftless Area occur anomalous topographic features not readily explicable in terms of processes now active. These features are especially prominent in the Baraboo and the Blue Mounds areas. At the latter place, boulder fields, boulder streams, and isolated rock masses, all derived from the Niagara chert, are found up to a mile from the outcropping ledges, and on slopes as low as 4°. In the Baraboo area, kindred features are developed on the pre-Cambrian quartzite. At many places, the bouldery accumulations are overgrown by vegetation, but in some places they are bare, save for lichens, and show the marks of long-continued weathering. Nowhere is there evidence of significant present-day movement. The features in question are "fossil" forms, and their present stranded appearance represents the cessation of a particular transporting process. Comparison with the "blockfelder," "felsenmeere," "blockströme," and related features described from arctic regions as products of modern frost action, and from central Europe as products of periglacial frost action, reveals similarities so pronounced as to indicate a corresponding origin. Thus the features described are best explained as having been formed through the action of frost weathering, frost heave, and solifluction induced by the rigors of the glacial climate in Wisconsin time. (Geological Society project.)

GEOLOGY OF THE CIMARRON RANGE, SANGRE DE CRISTO MOUNTAINS, NEW MEXICO

BY J. FRED SMITH, JR., AND LOUIS L. RAY

The Cimarron Range of north-central New Mexico, between the Ocaté Mesa on the south and the Cimarron Canyon on the north, rises abruptly more than 5000 feet above the Great Plains, which extend eastward from the mountain front. To the west the range is separated from the main mass of the Sangre de Cristo Mountains by the downfaulted Moreno Valley. The general trend of the Cimarron Range is north-south.

Rocks of the mountain core are pre-Cambrian crystallines. Along the eastern mountain front is exposed a series of sedimentary strata, Pennsylvanian to early Tertiary in age. Tertiary formations of the adjacent Raton Coal Basin are absent in most of the region studied. All pre-Tertiary formations are cut by a complex of dikes and sill-like bodies of quartz monzonite porphyry, whose ridgelike topographic expression is a conspicuous feature of the landscape.

Structure along the mountain front is similar to that of the Colorado Front Range, for flat-lying sedimentary strata of the plains are abruptly upturned along the mountain front. The Dakota sandstone makes prominent ridges. A normal fault follows the contact between the sedimentary strata and the pre-Cambrian rocks of the mountain core for more than 7 miles. Field studies indicate that the mountain mass is a northward-plunging anticline, broken by faulting.

In the southern portion of the mountains a volcanic vent, genetically related to some of the lava flows, is partially exposed in the valley of Rayado Creek. Dipping beds of ash and agglomerate surround a central leucophyride plug. This vent appears to be related to the fault along the mountain front. (Geological Society project.)

MINONG BEACHES AND WATER PLANE IN LAKE SUPERIOR BASIN

BY GEORGE M. STANLEY

A great interlude between Algonquin and Nipissing stages of the Great Lakes is now known to embrace, in addition to the lower Algonquin beaches, a set of much stronger, more recent beaches around the Lake Superior basin, termed the Minong series after the Isle Royale region where they were first traced. In 1941 they were definitely identified and traced along the east coast of Lake Superior between Goulais and Montreal River. At places near Montreal River they are strongly developed ridges of boulders and coarse rubble, devoid of plants, much like occurrences in Labrador and Hudson Bay.

Concerning the highest Minong beach and its water plane: (1) Northeastward rise is (a) 2.7 feet per mile over the Isle Royale region; (b) almost 4 feet per mile on the east coast near Montreal River. (2) Though at Goulais the Algonquin beach (elevation 1065) and others lie above the Minong (700), farther north at Montreal River the Minong is the highest shore line—*i.e.*, the Algonquin and lower Algonquin beaches ran out northward hereabouts against ice faces. (3) In duration the Minong ranks with Algonquin and Nipissing stages, outranks lower Algonquin stages. (4) The vertical interval of the series increases northeastward, indicating a period of uplift and southerly outflow. (5) The attitude of the water plane suggests that the outlet lay near the present outlet of Lake Superior, perhaps somewhat farther down St. Mary's River; on the other hand it seems possible from existing information that there was outflow northward for a time, toward James Bay, perhaps via Long Lake.

STRUCTURE OF THE LOS PINOS MOUNTAINS, NEW MEXICO

BY J. T. STARK AND E. C. DAPPLES

The Los Pinos Mountains form the southern part of a north-south-trending mountain group along the Rio Grande Valley in central New Mexico. Neither northern nor southern limits are clearly marked; the northern end of the Los Pinos is separated arbitrarily from the Manzano Range, and in the south the mountains merge with southward-dipping cuestas.

The pre-Cambrian core, the area of greatest relief, is composed of the Sias quartzite (oldest), Blue Springs muscovite schist (originally siltstones), White Ridge quartzite, and Sevilleta rhyolite, all intruded by the Los Pinos (pre-Cambrian) granite. The pre-Cambrian bedded rocks exceed 10,000 feet in thickness, of which nearly 4000 feet is rhyolite flows. All dip westward (average 50°), and schistosity parallels the dip. Schistosity of the Los Pinos granite (N. 20° E.) parallels that in other pre-Cambrian rocks. Granitization is pronounced along its borders, particularly along the contacts with the White Ridge quartzite.

Pennsylvanian and Permian strata unconformably overlie the pre-Cambrian rocks; they form cuestas on the east and south sides of the uplift, whereas, on the western flank, a normal fault downthrown on the west is suggested. The Pennsylvanian rocks consist of nonmarine sandstone and shale grading upward into marine limestone and shale. The latter commonly grade upward into nonmarine sandstone. Permian "red beds" (Abo sandstone) appear to lie conformably upon the Pennsylvanian.

Pre-Cambrian rocks have been thrust eastward overturning the Paleozoic sediments. Such faulting (Laramide) consists of two closely spaced north-south-trending thrust slices (40°-60° dips), the Montosa and Paloma. Some bedding-plane movements and normal faulting followed the thrusting.

MOVEMENT OF MINERALIZING SOLUTIONS IN THE PICHER DISTRICT, OKLAHOMA-KANSAS

BY RICHARD E. STOIBER*

The direction of flow of the mineralizing solutions was studied at many localities in the mines of the Picher lead-zinc district in Oklahoma and Kansas. Direction of flow was determined from a study of crystals deposited in open space by noting preferred growth on the stoss side of crystals, overgrowths of later crystals on the stoss side of earlier ones, and crystal deposition on the stoss side of irregularities in cavity floor or roof. The horizontal components of the flow directions indicate movement of the solutions away from the Miami Shear Trough approximately NE and NW to the NW of the trough and SE and SW to the SE of the trough, with little local variation. These directions are believed to indicate the pattern of the fractures along which solutions traveled in this area. Ore runs appear to have formed when the solutions reached the structures favorable for ore deposition described previously by other investigators. (Geological Society project.)

SEDIMENTS OF GRASSY LAKE, A LARGE BOG LAKE OF VILLAS COUNTY NORTHERN WISCONSIN

BY W. H. TWENHOFEL, V. E. MC KELVEY, AND S. L. CARTER

Grassy Lake and its more or less marginal bog cover an area of at least a square mile. At least half of the original basin is lake. The basin is a pit in glacial outwash

* Introduced by C. P. Berkey.

and it had an original maximum depth of about 35 feet. The present maximum depth of water in the lake is approximately 6 feet. The maximum depth of sediments measured is 30 feet 4 inches. These sediments, except at the immediate bottom of the column, are composed of between 65 and 70 per cent organic matter. This organic matter consists largely of a pale greenish-yellow gel in which are enmeshed detrital particles, diatom tests, sponge spicules, pollen grains, and more or less determinable particles of plant matter. The gel is in the form of flocules which are 2 millimeters or more in diameter. The average water content of the sediments is a little less than 95 per cent. The sediments are without stratification. Compaction without loss other than water would give a thickness of about 1.5 feet. This represents the total accumulation since the Ice Age. The sediments contain distillates which approximate 19 gallons per ton dry weight.

AERIAL EXPLORATION OF THE GREAT GLACIERS OF THE ALASKAN COAST AND INTERIOR

BY BRADFORD WASHBURN *

During the past 12 years the speaker has made 10 different expeditions into various sections of mountainous Alaska. Sponsored by the National Geographic Society, Harvard University, and the New England Museum of Natural History, they have yielded a wealth of over 3000 aerial photographs of one of the most interesting and spectacular glacier systems on earth.

The purpose of these expeditions was twofold: (topographic) to obtain material which has assisted in mapping several of Alaska's most isolated and rugged unexplored areas, and (geologic) to secure as complete as possible a series of aerial photographs, illustrating the fundamental principles of glaciation.

A selection of colored lantern slides will be presented, showing in detail the extraordinary morainic systems of Alaskan glaciers, the recent spectacular movements of several of the more important ice fronts, and some of the more interesting of the general features associated with the widespread retreat of the glaciers in this part of North America today.

MESOZOIC VOLCANIC SERIES IN SOUTHWEST OREGON

BY FRANCIS G. WELLS AND PRESTON E. HOTZ

Metavolcanic and metasedimentary rocks constituting a volcanic series that extends over an area of 700 square miles in the Medford, Grants Pass, and Kerby quadrangles, southwest Oregon, were mapped in 1938, 1939, and 1940. These rocks extend to the northeast and southwest beyond the area mapped. The general trend is to the NNE., and the rocks dip steeply. A major syncline or synclinorium and several minor folds have been recognized. From the Galice formation (Jurassic) on the west the series is separated by a steep reverse fault; on the east it passes under Cretaceous and Tertiary formations.

The series is composed predominantly of basaltic flows, breccias, and tuffs with intruded diabase and gabbro that have been spilitized. Interbedded sedimentary rocks in the approximate order of their abundance include argillite, chert, quartzite, sandstone, and a few lenses of limestone and conglomerate. They make up less than 15 per cent of the mass and occur in units usually less than 5 miles long and a few hundred feet thick. Adjacent to large quartz diorite intrusions the rocks

* Introduced by M. P. Billings.

have been metamorphosed to schist, hornfels, and marble. This group of rocks probably exceeds 30,000 feet in thickness.

Poorly preserved fossils collected by J. S. Diller from the limestone lenses of the series were long ago identified as Devonian. Diller's collections, on restudy, and those made by the writers have been determined by J. B. Reeside, Jr., to be definitely Mesozoic and probably Triassic; no basis is left for the record of Devonian in this series. A formal name will be applied to these rocks.

SOIL AVALANCHES IN HAWAII

BY CHESTER K. WENTWORTH

Shallow soil avalanches are normal factors in slope adjustment in wetter, maturely eroded, mountainous parts of Hawaii. The slides occur on 45- to 60-degree, vegetation-covered slopes at times of exceptionally heavy rains. The material moved consists usually of a thickness of only 2 or 3 feet of mantle rock, and the slide exposes the striated edges of the more resistant of somewhat weathered lava flows. The avalanches commonly involve a length, on the slope, of several hundred feet and a width that is only a small fraction of the length. At the upper limit of the slide, often near the ridge crest where trees may be larger, the soil and vegetation of the crest are usually left perched, and repeated slides on the two sides of the crest seem to be among the most potent causes of the remarkably narrow and steep-sided "knife-edge" crests of the region.

The avalanches are due to frictional failure and should be distinguished from the larger slides of the "Panama" type which are due to shearing failure of the material along a characteristic curved surface. Slides of the latter type occur in Hawaii but are not dealt with in this paper. One of the important consequences of the soil avalanches is the repeated baring of surfaces on which sufficient soil and partly weathered rock remain so that a new plant succession is started, in which some introduced plants may take an exaggerated part. Spreading of such plants has been attributed to trail construction and use, the work of wild pigs, and to erosion induced by grazing, but it should be recognized that, apart from any of these animal disturbances, the normal geomorphic process affords considerable baring of the surface through these soil avalanches, with an attendant ecological evolution according to the plants which are found currently in the region.

REVISED CAMBRO-ORDOVICIAN CORRELATIONS

BY ROBERT R. WHEELER *

Revisions in the Champlain, Hudson, Mohawk, and St. Lawrence valleys (Adirondack-Border region) involving definitions and succession of previously accepted Cambro-Ordovician formations (the Upper Cambrian Potsdam, Theresa, Hoyt, and Little Falls and the Lower Ordovician Whitehall, Tribes Hill, and Beekmantown) are as follows: (1) the lower "typical" Theresa is physically and faunally differentiated from the "Upper Theresa" (now the Heuvelton member of the Tribes Hill formation); (2) the Hoyt fauna occurs in the lower half of the emended Whitehall formation above the Little Falls dolomite; (3) a new, upper (Skeene) member of the Whitehall formation represents late Cambrian offlap; (4) two marine cycles, represented by the Tribes Hill formation (containing the Norton=Heuvelton, Fort

* Introduced by P. E. Raymond.

Ann=Bucks Bridge, Benson=Ogdensburg members) and the Cassin formation, constitute the Beekmantown series. Each revised unit is tied in with the Divisions A through E of the original "Calciferous" formation.

The late Cambrian Hoyt fauna has affinities with that of the Trempealeau, Conococheague, and Eminence; whereas the Oneota, Stonehenge, Van Buren, and Gasconade faunas occur in the Tribes Hill formation, not in the Little Falls as generally believed. Thus, the lower half of the Ozarkian is Cambrian, and the upper half is Lower Ordovician.

Sedimentary and faunal data permit the solution of facies problems, paleogeographic inferences, and reconstruction of marine cycles in which the position of the deposits of maximum and minimum transgression are utilized as datum lines to ascertain time-transgression relations.

BENTONITE AND UNCONFORMITIES

BY LAWRENCE WHITCOMB

Unconformities between Ordovician strata in the eastern United States have been placed upon bentonite beds. The nature of this material is such that its capability of preservation on an erosion surface is very doubtful. It is significant that bentonite was not reported from these beds until 1921. Prior to this date when paleontologic evidence indicated the presence of an unconformity within a limited stratigraphic distance it was common practice to place the break at a clay seam if one were present. This was done on the assumption that the clay was the reworked soil on the old land surface. The presence of the unconformity is not doubted, but the bentonitic character of the clay strongly suggests that the stratigraphic horizon of the unconformity has not been accurately determined. The long-distance correlation of unconformities that are placed at bentonite beds is also very doubtful because of the nature of the distribution of the ash. All unconformities and stratigraphic breaks so placed should be restudied.

STRATIGRAPHY OF NORTHEASTERN AROOSTOCK COUNTY, MAINE*

BY W. S. WHITE, P. E. CLOUD, JR., AND JOSIAH BRIDGE

Mapping in northeastern Maine in the summer of 1941 has resulted in tentative revision of and addition to the local stratigraphic sequence.

In addition to the black shale with Normanskill graptolites, found by Nylander in 1934, two new horizons of Ordovician age can be recognized. One consists of greenish slate with trinucleids and other fossils, the other of bluish calcareous siltstones and pyroclastic rocks with orthids and other fossils. The structural and stratigraphic relations of the Ordovician rocks are not known.

The Silurian—several thousand feet thick—is represented by three units. The lowest is a predominantly clastic and locally fossiliferous series formerly called the Sheridan sandstones. Following this is the Aroostook formation or group, a thick sequence of interbedded limestone, slaty limestones, and slates, generally unfossiliferous. In the vicinity of Presque Isle four subdivisions of the Aroostook strata have been mapped, and a few fossils obtained from the uppermost division. Above the Aroostook beds lies the Ashland formation of *Monograptus*-bearing calcareous

* Presented with the permission of the Director, Geological Survey, U. S. Department of the Interior.

mudstones and siltstones with local lenses of highly fossiliferous limestone breccia. These lenses were formerly given a formation name, the Ashland limestone, but they do not appear to constitute a stratigraphic unit, and the writers agree with Twenhofel in regarding their separation as unsound.

Besides the Chapman and Mapleton sandstones a new Devonian formation was mapped. This is a pyroclastic series subjacent to the Chapman sandstone and believed to be the parent rock for boulders with a New Scotland fauna found by Nylander.

GEOLOGIC RELATIONS AT LAKE DAMARISCOTTA, MAINE

BY BRADFORD WILLARD

Lake Damariscotta in Lincoln County, Maine, is about 50 miles northeast of Portland. The lake, 10 miles long by ½ to 1 mile wide, trends N. 25° E. Its dimensions, shape, and position reflect the bedrock geology. The 1933 State geologic map shows this entire area as pre-Cambrian gneisses, schists, pegmatites, and schistose granites. Field studies disagree with these findings. Observations in the vicinity of Great Bay at the north end and a reconnaissance completely around the lake show that it occupies a depressed area of quartzite or quartz schist. Most of its outcrops are near lake level, about 50 feet above sea level. Quartz veins and a few basic dikes cut this formation. Although unproven as yet, it appears not improbable that the quartzite is a correlate of some of the Middle Paleozoic formations in the vicinity of Lewiston to the northwest. The hills west of the lake are of granite gneiss which locally passes into porphyritic gneiss. The gneiss carries inclusions of the quartzite, thus determining the relative ages of these rocks. East of the lake glacial drift conceals much of the bedrock. The country rock has a structural trend of N. 25°-30° E., parallel to the major topographic features. Thus, Lake Damariscotta lies in a quartzite-floored valley bounded by granite gneiss hills. Glaciation of the valley is attested by its form and the abundance of glacial material present. The unequal resistance between quartzite and gneiss and the trend of the rocks appear to be the determining factors for the form and position of the lake.

TRIASSIC FLOOR OF DEPOSITION NORTH OF HOLYOKE RANGE, MASSACHUSETTS*

BY MAX E. WILLARD †

The general topography of the Triassic floor of deposition in the area north of the Holyoke Range is indicated by the effects it has had on the thickness, distribution, and textural variation of the Triassic sediments. This topography is further revealed by isolated exposures of pre-Triassic crystalline rocks within the area now largely covered by Triassic.

The evidence seems to indicate a sharp break in the topography of the Triassic floor along a probable fault line that trends approximately north-south in the longitude of North Sunderland. East of this line the pre-Triassic rocks are relatively near the present surface; west of it they are at depths of several thousand feet. The eastern elevated area is broken near the present eastern limit of Triassic rocks by a zone of faulting and silicification that trends approximately north-south. The western fault scarp, now buried, seems to have been the eastern limit of an early

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† Introduced by L. W. Currier.

Triassic basin of deposition. This basin was filled, at least in part, when structural adjustments along the zone now faulted and silicified created a second north-south-trending basin. In this second basin were deposited the sediments that make up the Mount Toby conglomerate and the so-called Leverett breccia.

CORRELATION OF THE BLEDSOE LIMESTONE WITH THE LEGO AND DECATUR LIMESTONES OF THE WESTERN TENNESSEE VALLEY*

BY CHARLES W. WILSON, JR.

Foerste (1901) named the Bledsoe (Niagaran) limestone from exposures near Bransford, Sumner County, Tennessee, where it occurs between the Waldron and Chattanooga shales. Northward he correlated it with the Louisville limestone but he found no certain equivalent in the Western Tennessee Valley. At Bransford the lower 20 feet of the Bledsoe is massive, sugary, dolomitic limestone, while the upper 60 feet is massive, medium to coarse, white to gray, pink-speckled, crinoidal, partly dolomitic limestone.

It is believed that (1) The lower 20 feet represents the lower Lego limestone of the Western Valley, the upper Lego having been eroded; (2) the upper 60 feet represents the Decatur limestone of the Western Valley; and (3) there is an unconformity 20 feet above the base of the Bledsoe that represents the upper part of the Lego and the Dixon, Beech River, Bob, and Lobelville formations, or about 175 feet of Niagaran strata.

The Lego equivalent in the Bledsoe is essentially unfossiliferous and was identified by (1) its conformable position upon the Waldron shale and (2) lithology of beds of undolomitized limestone. The Decatur equivalent in the Bledsoe was identified by (1) numerous species of Niagaran corals that were also found in the Decatur of the Western Valley, (2) close facieological similarity to the Decatur, which, moreover, is the only limestone in the Western Valley lithologically similar to the upper 60 feet at Bransford that maintains this thickness over a considerable area, (3) association of *Astreospongia meniscus* with the Decatur facies, and (4) the fact that the Decatur is the only Niagaran formation of the Western Valley known to be unconformable.

COLOR AS A GUIDE IN TERTIARY CONTINENTAL STRATIGRAPHY

BY HORACE ELMER WOOD, 2ND

Over the Rocky Mountains and Great Plains, the colors and erosional patterns of the Tertiary deposits have long been used in correlation to supplement the localized fossil pockets. Where color varies locally in intensity, the erosion pattern usually remains fairly constant. Paleocene beds are typically drab, yellow, with lignite streaks. With the lower Eocene, red banding appears, first influenced by Paleocene colors, then showing pronounced clarity, alternating with gray. With middle Eocene, red gives way to gray and gray green, as volcanic ash appears. Hematitic red appears again toward the top of the Eocene and in earliest Oligocene. The lower Oligocene is typically gray to chocolaty; middle and upper Oligocene are pale buff; Miocene and Pliocene are light gray to nearly white. Kodachrome, used with discretion, can furnish a valuable technique for objective record and comparison of the general aspect of noncontiguous deposits. (Geological Society project.)

* Presented with the permission of the State Geologist of Tennessee.

GEOLOGIC CORRELATION OF AREAL GRAVITATIONAL AND MAGNETIC STUDIES IN NEW JERSEY AND VICINITY

BY GEORGE PRIOR WOOLLARD*

One thousand nine hundred and thirty gravitational and magnetic stations were established to study the regional extent and distribution of large-scale anomaly variations, and also the effect of local geologic structural and lithologic variations on the observed anomalies. About half the stations were distributed with an average station spacing of 4 miles on profiles across an area extending from the northern tip of New Jersey to Cape Cod, Massachusetts, and southward to Cape Henlopen, Delaware, Washington, D. C., and Harrisburg, Pennsylvania. The balance of the stations were concentrated in a strip 4 miles wide extending from Barnegat Bay to Phillipsburg, New Jersey, with a station spacing of .3 mile on traverses about a mile apart.

The survey shows the presence of several previously unknown anomaly areas as well as the extent of those known from earlier investigations, and the trend of all these anomalous areas parallels the structural trends of the Appalachian Mountain system. On the more detailed survey marked local anomalies are superimposed upon the large regional features. These local variations reach their greatest magnitude in the area of exposed pre-Cambrian and Lower Paleozoic rocks, and these same lithologic types appear to control the local anomalies in both the Triassic and Coastal Plain areas except where there is intrusive diabase. Depth of sediments, structural displacement, and basement surface configuration apparently exert only a minor control in these areas on the anomalies as compared to the basement lithology. Similarly, the large regional anomalies appear to be related to intra basement lithologic variations.

CERRO COLORADO, ISOLATED NONBASALTIC VOLCANO IN CENTRAL NEW MEXICO

BY HERBERT E. WRIGHT, JR.†

Cerro Colorado is an old volcano about half a mile in diameter and 300 feet high, conspicuously located in the Rio Puerco valley in central New Mexico, about 15 miles west of Albuquerque. It is an isolated occurrence of intermediate as contrasted to basaltic lava, 25 miles from its nearest possible counterpart.

The lavas and pyroclastics of an early volcanic cone of trachytic composition are interbedded on the east flank with contemporaneously deposited sandstones. The vent of this early cone was plugged by a funnel-shaped mass of intrusive latite and latite breccia. The well-developed flow banding dips inward 30°-60° near the margins of the mass and is nearly vertical at the center.

Erosion reduced the volcano to little more than a plug. The hill was then buried in the late Tertiary by sands of the upper portion of the Santa Fe formation. Reddish slope wash from the hill interfingers with the onlapping buff Santa Fe sands. Quaternary erosion has re-exhumed the old hill slope.

The age of the volcanic eruption cannot be determined directly, for the sandstones with which the pyroclastics are interbedded are similar both to early Santa Fe and to upper Cretaceous sandstones of the region. In consideration of the Tertiary history of New Mexico, however, the age is probably post-Eocene and may be as late as Miocene.

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* Introduced by C. P. Berkey.

† Introduced by Kirk Bryan.

CORDILLERAN SECTION MEETING AT STANFORD UNIVERSITY IN APRIL

WORK OF WIND IN NORTHERN LAKE COUNTY, OREGON

BY IRA S. ALLISON

Deflation on the floor of an extinct Pleistocene lake in the Fort Rock-Christmas Lake-Fossil Lake basin of northern Lake County, Oregon, has developed several basins in the lake sediments having depths of tens of feet and lengths of several hundreds of feet. Part of the material removed is piled up on the leeward rims. Post-lacustrine pumice, probably in part at least the eastward extension of the Crater Lake pumice field, has also been piled up in long transverse dune ridges. In the Fossil Lake sector lake beds have been wind-cut over an extensive area, and a leeward train of dunes of varying forms has been blown across country as much as 12 miles.

SUBDIVISIONS OF THE CHICO SERIES

BY FRANK M. ANDERSON

The major stratigraphic groups of the Chico series—Pioneer, Panoche, and Moreno—can each be subdivided into smaller units based in part upon observed diastrophic disconformities, in part upon faunistic characteristics, and in part upon lithological features or changes that seem to have followed earth disturbances in other regions, which resulted also in faunal changes here.

The subdivision of the Pioneer group into formational units is entirely practicable, since each of its divisions rests directly upon basement rocks over wide areas in which the other division is not present.

The Panoche group, constituting half the stratigraphic sequence of the series, is not simple in faunistic aspects; it presents a succession of faunal assemblages which provide criteria for an analysis of its stratigraphic column in terms of historical events and episodes of great moment. Not less than five distinct faunal assemblages of formational (historical) significance are recognizable in its column, each clearly related to assemblages known in widely scattered regions about the Pacific borders, that severally must be regarded as having had distinct connections with those in the Great Valley of California.

From these the development of a standard faunal column of reference in the Chico series of value in the historical study and correlation of deposits throughout West Coast areas is practicable and important to students of Mesozoic history in all Pacific border regions and in countries outside of them.

LAKES OF TWO AGES IN SEARLES BASIN, CALIFORNIA

BY ELIOT BLACKWELDER

Searles Lake in southeastern California is now a salt plain, but the basin was formerly occupied by a lake more than 500 feet deep. A study of the ancient shore lines indicates that the higher ones are much older than the lower. This marked difference in age is evidenced by the degree of erosion of gravel bars, by the state of decay of pebbles on these bars, but most clearly by the conspicuous difference in weathering of the tufa deposits. Large tufa domes and towers on the lower shore lines are as yet only slightly damaged by weathering, whereas those on the uppermost shore lines have suffered so much from solution that they are now rusty, cavernous, and partly tumbled down. These older shore lines have been traced into the former

outlet southeast of the lake, but the actual channel has been obliterated at the divide by the advance of alluvial fans.

From a general study of desert basins in this region it is regarded as probable that the expansion of Searles Lake took place in late Pleistocene time and that the two stages here suggested may be correlative with the Tahoe and Tioga glacial stages in the Sierra Nevada.

Although the evidence appears to be clearest around Searles Lake, there are similar indications in several other basins of the arid Southwest.

SIGNIFICANCE OF RAIN PRINTS

BY ELIOT BLACKWELDER

Current allusions to rain prints on shales suggest a rather general misunderstanding of their significance. Field observations by the writer and laboratory experiments by Robert L. Loofbourow indicate that good rain prints are formed on clay only when it has just the right viscosity, due to the addition of about 60-120 per cent (by weight) of water. If more water is present prints are made, but the clay is too fluid to hold the form, and so they disappear in a few seconds. If there is much less water the mud is so stiff that good impressions are not made. Silt and fine sand require less water than clay but are favorable in consistency only within a much narrower range—70-90 per cent and 30-40 per cent in two instances tested.

The best conditions for rain prints appear to be (1) a surface of recently deposited clay, partly dried out to the right consistency, (2) a slight sprinkle of rain soon followed by prolonged sunshine, and (3) a prompt covering by wind-blown sand or dust. If the sprinkle develops into a shower all the prints made will be destroyed.

Hailstones can make deep prints in mud, but none appear to have been identified in rock strata or observed in process of formation in the field. Their absence may be due to the fact that hail develops only during a heavy rain storm, and such a rain would either make the clay surface too wet to permit the formation of stable prints or would obliterate them even if made.

IMPERIAL VALLEY EARTHQUAKE OF MAY 18, 1940

BY JOHN P. BUWALDA AND CHARLES F. RICHTER

This shock was of unusual geological interest because it was accompanied by a surface fault rupture about 40 miles long, proving that a previously unsuspected, active fault passes along the middle of Imperial Valley. The new trace is entirely in the alluvium of the Colorado River cone, is substantially straight, trends about N. 35° W., and presumably marks one branch of the San Andreas fault system. It extends from near Brawley southeastward, passing east of El Centro, and about 20 miles into Mexico. We designate it the Imperial fault. The southwest side of the fault moved northwestward, offsetting the International Boundary, All-American Canal, and neighboring roads, fences, and orchard rows about 15 feet. This displacement seems disproportionately large, approaching that of the much greater San Francisco earthquake. Vertical offset, maximum about 4 feet, changes rapidly in amount and alternates from side to side along trace. The shock was comparable in magnitude to Long Beach 1933 and Santa Barbara 1925. About nine lives were lost; property damage, involving canals, buildings, crops, highways, and bridges, aggregated perhaps $5.000.000. The shock occurred at 8:36:40 p.m. The instrumental epicenter is at 32° 46.5′ N., 115° 9.1′ W., near the trace about 10 miles from its northern end.

There were no immediate foreshocks. Aftershocks were numerous; one at 9:50 p.m. was reported as stronger and more damaging at Brawley than the main shock. This presumably originated on the northern part of the moving fault segment.

ICHTHYOSAURS FROM THE FRANCISCAN FORMATION OF CENTRAL CALIFORNIA

BY CHARLES L. CAMP

Two ichthyosaur rostra enclosed in worn chert cobbles have recently been discovered in Quaternary gravels on the west side of the San Joaquin Valley. The character of the chert and the associated Radiolaria definitely indicate derivation from the adjacent Franciscan chert beds.

Characters of the teeth and the shape and relations of the bones and canals in the snout seem to show close relationship to ichthyosaurs from the Upper Jurassic of Europe, particularly *I. posthumus* from the Solenhofen beds of Tithonian (Lower Portlandian) age. *I. australis* from the Lower Cretaceous of Queensland also appears to be related. Some of the ichthyosaurs from the Upper Jurassic are very similar to forms in the Lower Cretaceous, but the Triassic and Lower Jurassic ichthyosaurs are most certainly not comparable with the two Franciscan species at hand.

AGE OF THE DALLES FORMATION

BY RALPH W. CHANEY

The Dalles formation, exposed east of the Cascades in northern Oregon, was originally assigned to the Pliocene by Condon in the 1860's. Subsequently it has been referred to Cenozoic horizons ranging from Upper Eocene to Pleistocene. The position of these volcanic sediments above the Columbia River lavas restricts them to an age younger than Middle Miocene. Their structure as commonly interpreted indicates that they were deposited before the Cascade uplift. Mammalian remains are few, suggesting an early Pliocene or late Miocene age. Plant fossils definitely indicate an age not earlier than Lower Pliocene. When these are compared with a larger flora from the Ellensburg formation of Washington, in which mammalian remains are also well represented, the contemporaneity of the Dalles formation is readily established, and the age of both formations may be indicated as Pliocene.

EVIDENCE FOR A PERSISTENT TERTIARY POSITIVE AREA EAST OF MOUNT DIABLO, CALIFORNIA

BY BRUCE L. CLARK

This paper describes a series of overlaps, beginning with the upper Cretaceous and ending with the upper Miocene. The Tertiary section, as found in the section due north of Mount Diablo, not including the Pliocene deposits, has a maximum thickness of close to 9000 feet. This includes about 8000 of Paleocene, Eocene, and Oligocene deposits. In a distance of about 15 miles to the southeast, on the eastern portion of the Byron quadrangle, the upper portion of the upper Miocene, the Neroly formation, rests unconformably on upper Cretaceous deposits; these are correlated with deposits of the upper Panoche group. Several thousand feet of upper Cretaceous deposits, represented in the section north of Mount Diablo, is missing in the latter area. This paper discusses the details of a series of overlaps which brought about the differences between the two sections. The conclusion is that there was a persistent positive area near the northern end of the San Joaquin Valley.

GEOLOGIC RECONNAISSANCE ACROSS THE CORDILLERA ORIENTAL, COLOMBIA, SOUTH AMERICA

BY THOMAS CLEMENTS *

In 1939 the author made a geologic traverse across the Cordillera Oriental of Colombia, South America, for the purpose of correlating the little known geology of the east side of the mountains with the better known Magdalena Valley section. The traverse was made along the road from Cambao on the Magdalena River, through Bogotá, to Villavicencio at the edge of the Llanos, a distance of 270 kilometers.

The oldest rocks encountered on the traverse were a thick series of phyllites and schists, occurring on the east side of the mountains, and considered to be Paleozoic. These are overlain by a great thickness of lower Cretaceous sediments, with a coarse conglomerate at the base, followed by black, slaty shales and limestones, containing numerous fossils. Lithologically similar strata occur near the foot of the mountains on the eastern side, faulted against the Paleozoics, and fossiliferous Lower Cretaceous rocks are found also on the west side of the mountains. The crest of the range consists largely of Upper Cretaceous sandstones and shales, the former predominating, and these rocks also form the great western scarp of the Cordillera.

Tertiary sediments of Eocene, Oligocene, Miocene, and possibly Pliocene age occur on the crest of the mountains and on both flanks. Continental in origin, they contain few fossils, and correlation is difficult.

Intricate folding characterizes the Cretaceous rocks, and several large faults, occurring on both sides of the mountains, further complicate the problem of correlation.

FOSSIL FISH FROM THE CENOZOIC OF CALIFORNIA

BY LORE R. DAVID †

Three depositional units in the Miocene have yielded important fish fossils:

(1) Modelo formation. Three faunas are recognized in the eastern part of the Santa Monica Mountains: (a) and (b) Lower Modelo, lithologic units 8 and 9 of type Modelo; (c) Upper Modelo, upper part of lithologic unit 9 of type Modelo. A younger Modelo fauna occurs in Sulphur Canyon (Ventura Co.). There are numerous other occurrences.

(2) Altamira and Valmonte members of the Monterey shale in the Palos Verdes Hills. Fish fossils in the Altamira (Zone D to E) are the oldest to be recognized thus far in California.

(3) Monterey shale of the Santa Maria Basin and southward to Santa Barbara. Most numerous fish fossils occur in these deposits, especially in the Lompoc diatomite (lithologic unit 18 of type Modelo).

A survey of the fish faunas from these deposits indicates a subtropical climate in middle Miocene time, changing gradually to a warm temperate climate in the upper Miocene.

All assemblages accumulated at medium depth (deep neritic-bathyal facies). The bathypelagic fish fauna was well established during middle to upper Miocene time. The neritic fish fauna has undergone important change since this epoch. Miocene faunas from the Pacific and Atlantic coasts of America showed greater resemblance during the Miocene than they do today.

* Introduced by J. P. Buwalda.
† Introduced by Chester Stock.

Pliocene fish occur in Pico formation near San Fernando.
Pleistocene fish are known only by fragmentary remains (teeth).
The variety of fresh-water fish recorded is small. (Geological Society project.)

STRATIGRAPHY AND STRUCTURE OF SOUTHWEST SAYPO QUADRANGLE, MONTANA

BY CHARLES DEISS

The Saypo quadrangle, in northwestern Montana, lies between parallels 47°30′ and 48° and meridians 112°30′ and 113°, and contains parts of the Lewis and Clark and the Sawtooth Ranges and part of the northern Great Plains. Stebinger mapped the geology east of the mountains before 1918, and the writer began mapping it in the mountains in 1940 for the United States Geological Survey.

The stratigraphic column, approximately 14,500 feet thick, consists of 18 formations: four Pre-Cambrian, nine Cambrian, and one each Devonian, Mississippian, Jurassic, Lower Cretaceous, and Upper Cretaceous. Pleistocene drift and Recent alluvium lie on all older rocks. Pre-Cambrian and Cretaceous sediments contain gabbro?-diorite sills. Disconformities occur between Cambrian and pre-Cambrian, Devonian and Cambrian, Mississippian and Devonian, and Jurassic and Mississippian formations. None are strongly angular.

The region contains two structural provinces: an eastern province characterized by westward-dipping high-angle thrust faults which broke steeply dipping Paleozoic and Mesozoic sediments, and a western province characterized by westward-dipping low-angle overthrust faults and westward-dipping high-angle normal faults which broke the pre-Cambrian and older Paleozoic sediments. Folds are subordinate to faults, both in numbers and importance.

All major structures probably formed during the Laramide orogeny. Its earlier compressional phase produced open folding, then high-angle thrusting, and finally low-angle overthrusting. The later tensional phase resulted in low-angle normal and, toward its close, in high-angle normal faulting.

PLEISTOCENE LAKE SEDIMENTS OF NORTHERN LAKE COUNTY, OREGON

BY HOLLIS M. DOLE*

Lake sediments of Pleistocene age from the Fort Rock-Christmas Lake-Fossil Lake basin of northern Lake County, Oregon, obtained mainly from the sides of wind-excavated hollows, have been subjected to petrographic analysis. The bulk of the material consists of altered pumice and diatoms. The pieces of pumice range from fine dust to pebbles. The pebbly pumice resembles the Newberry type more than the Crater Lake type, but both sources may have contributed pumiceous material. Phenocrysts are mainly andesine, labradorite, and hypersthene. Induration and cementation have been slight.

CALIFORNIA QUICKSILVER STUDIES BY THE GEOLOGICAL SURVEY†

BY EDWIN B. ECKEL

The paper summarizes the aims, purpose, and accomplishments of a part of the Federal Geological Survey's strategic minerals program—that on California quicksilver deposits. The principal objective of the program is an inventory of mineral

* Introduced by Ira S. Allison.
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supplies essential to national defense or security. Reserves of ore, both probable and possible, rate of production maintainable at given prices, and discovery of areas worthy of prospecting must all be determined. This necessitates geologic examination of every district, mine, and prospect, and correlation of data thus obtained. Methods of examination must vary with individual projects, but all work is highly objective. Conclusions must be based on sound geologic field work, but scientific results must be subordinated to attainment of the practical requirements of the emergency. Since mid-1939, five projects of varying size have been completed, and reports are either published or will be available shortly. Three projects now in progress, to be finished by July 1941, will complete essentially all districts south of San Francisco, after which extensive studies in Lake and adjoining counties will be commenced. The entire program will require from 3 to 6 years, depending on time, money, and men available. It is expected to yield reasonably sound estimates as to reserves and possible rate of production, and to have delimited favorable prospecting ground. A comprehensive report, assembling and correlating information on all California deposits, is contemplated as a climax to the program.

QUICKSILVER DEPOSITS AT NEW IDRIA*

BY EDWIN B. ECKEL

Recent studies in the highly productive New Idria district are described as an example of the Geological Survey's strategic minerals program. The 80-square mile mapped area is characterized by a large oval body of serpentine, rimmed by Franciscan sandstone and by Cretaceous and later sediments. The structure is that of an asymmetric anticline, marked on the northeast flank by overturned beds and by an irregular thrust fault along or near the Franciscan-Cretaceous contact. Like most quicksilver deposits, the cinnabar ores are in the most favorable rocks that were accessible to rising ore solutions. Several minor deposits occupy fracture zones in Franciscan sandstone and in serpentine. At the New Idria mine, however, soft and generally unfavorable Cretaceous shale and sandstone were rendered most favorable structurally by pre-ore silicification of distorted beds immediately beneath the thrust fault. All known deposits and ore shoots are in places where maximum openings were developed during thrusting. Changes in strike, due to bends in the fault plane or to tear faults, control most of the deposits, but dip changes are locally important. Reserves of assured and probable ore are comparatively large. In addition, known geologic relations offer much hope for the discovery of new ore bodies in the future.

APPLICATION OF THE SPECTROSCOPE TO ORE FINDING

BY H. J. FRASER AND H. D. B. WILSON

Development of the quantitative spectroscopic technique has made available a new tool of possible use in the localization of ore bodies within a mineralized zone. Vein quartz, free from any megascopic impurities, may show 20 elements or more present in quantitatively measurable amounts. A number of these elements may show significant variations between areas of economic mineralization and barren parts of the vein or silicified wall rock. From a study of these variations it is possible, under certain conditions, to predict whether one is approaching or going away from an ore body.

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THRUST FAULTING IN THE DRAGOON MOUNTAINS, ARIZONA*

BY JAMES GILLULY

In the Dragoon Mountains, pre-Cambrian schists and intrusives are overlain by a Paleozoic section, essentially conformable Cambrian to Permian. These rocks were deformed and invaded in pre-Cretaceous time. The irregular erosion surface later formed was buried by Comanche sediments. Tertiary(?) volcanics unconformably overlie the Comanche.

The principal deformation was post-volcanic. Large thrusts carried the older rocks eastward over the Comanche and volcanics. At the south end of the range there are thick masses composed of individually thin plates of rocks of all ages, interleaved without regard to normal stratigraphic relationships; they are probably gigantic breccias along the erosion surface overridden by the major thrust. The probable root of the thrust is here occupied by intrusive felsite. Farther north, both this breccia and the postulated overlying thrust block have been eroded away, but the Cretaceous rocks are overturned to low dips for nearly 4 miles across the strike and are cut off on the west by steeply dipping thrust sheets of Paleozoic rocks. In the middle of the range at least three such thrusts occur. Farther north a large post-thrust granite has engulfed several square miles of the thrust masses and possibly domed them slightly. The north end of the range exposes only rocks above the basal thrust.

Northwest-trending normal faults (Pliocene ?) cut all the older structures.

CATACLASTIC GOLD QUARTZ VEINS

BY G. E. GOODSPEED

Recent studies of gold quartz veins by several workers have shown that recurrent fracturing is an important factor in the mechanism of vein formation. Most of these veins may be assigned to the mesothermal hydrothermal zone, which from a structural standpoint might be expected to be particularly amenable to cataclasis.

Cataclasis with concomitant recrystallization during the process of vein formation tends to obscure or obliterate evidence diagnostic of former filling or replacement. However, the alignment of microinclusions limited to individual quartz crystals, and parallel to crystallographic planes in the crystals, may be indicative of their formation in a relatively mobile environment. Local occurrence of relic comb structure denotes precipitation from solution in an open cavity. On the other hand, phantom relics of either altered rock or crystal fragments included in several anhedra of quartz irrespective of crystallographic planes and crystal boundaries suggest replacement rather than filling as the earlier mechanism.

Microstructures of some cataclastic quartz veins bear a striking resemblance to those of some mylonitic rocks. Many cataclastic veins are apparently the loci of zones of intense shearing. These veins are commonly of great lateral and vertical extent, whereas associated aclastic veins such as gash-filled fissures may be of relatively limited extent. Hence, in mining, the recognition of cataclastic quartz especially in diamond drilling may be a most important factor in the planning of exploratory work. Since cataclastic and aclastic quartz may be very similar megascopically, a petrographic study of microstructures is usually required to distinguish them.

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MECHANISM OF FAULTING IN SOUTHERN CALIFORNIA INDICATED BY SEISMOGRAMS

BY B. GUTENBERG

Study of the direction of the first impulse (compression or dilatation) in about 4100 seismograms recorded at California stations from about 1700 local earthquakes leads to the following conclusions:

(1) The results strongly support the rebound theory.

(2) In almost all of the earthquakes the block on the northeast side of the fault moves toward the southeast relative to the other block. Vertical movements are relatively small.

South of the Transverse Ranges the directions of the movements with few exceptions are very uniform from the margin of the continental shelf to beyond the San Andreas fault, where the shocks become scarce. There is no difference between the larger shocks on the major faults and the many small shocks scattered between them. Reversed movement has occurred in only a few instances, if at all. North of the Santa Monica Mountains the fault pattern complicates the picture, but there is no evidence that this area does not conform to the general results. In the Sierra Nevada some movements of another type are indicated. Most of the shocks in western Nevada begin at the two Owens Valley stations with the direction to be expected if this region is included in the general movement.

(3) Southern and central California, including the shelf, are under a shearing stress such that its tendency is directed toward the southeast in the crustal layers of the continent relative to the crust beneath the Pacific.

CHROMITE DEPOSITS OF THE DEL PUERTO AREA, CALIFORNIA*

BY HERBERT E. HAWKES, JR. AND DOOLEY P. WHEELER, JR.†

The chromite deposits of the Del Puerto canyon area, Stanislaus County, California, occur in an elongate body of ultrabasic rocks which trends N.70°W. and is roughly a mile wide in the vicinity of the deposits. The rocks of the igneous complex in the probable order of emplacement are: (1) peridotite containing 20 per cent pyroxene and 80 per cent olivine; (2) dunite; (3) veins and irregular masses of pyroxenite; (4) a later complex of gabbros, diorites, and more acidic rocks. Dunite forms the core of the intrusion and is flanked by peridotite except where later gabbros have complicated the structure. The peridotite and dunite have been partly serpentinized. All contacts between the igneous and sedimentary rocks are marked by zones of intense shearing.

All the chromite of any significance is in or very closely associated with dunite; the peridotite is commonly utterly barren. Three important types of chromite occurrence were recognized: (1) accessory grains as much as 1 mm. in diameter scattered throughout the dunite; (2) aggregates of grains of similar size and shape in irregular or sheetlike bodies containing as much as 40 per cent chromite by volume; (3) lenses of massive, generally very compact chromite in zones of shearing. All the chromite of commercial grade has been of the last type. Two variations in the structure of the massive type of ore were noted: (1) lenticular or sheetlike bodies a few inches thick, parallel to the trend of the shear zone, and showing sharp contacts with barren silicates; and (2) irregular veinlets and stringers of chromite apparently following joints and enveloping breccia fragments in the shear zone.

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† Introduced by Aaron C. Waters.

FAULTING IN THE NORTHERN PROVIDENCE MOUNTAINS, SAN BERNARDINO COUNTY, CALIFORNIA

BY JOHN C. HAZZARD *

Near Kelso on the western front of the range, a prominent salient is cut by two major and several minor normal faults which strike about N.20°E. and dip about 25°NW. On one of the major faults the stratigraphic displacement determinable within the Paleozoic section is 4000± feet; on the other it is 1600± feet. It is suggested that these low-angle faults owe their present attitude to a 40±-degree eastward tilting of the present mountain block after their development.

The major portion of the eastern margin of the range is an obsequent fault line scarp developed along a high-angle reverse fault dipping from 65°-75° E. and trending nearly N.-S. On the western side of this fault are Paleozoic rocks of the high-standing mountain block and on its eastern side are pre-Cambrian gneisses and granites which underlie the northern end of Fenner Valley; thus the structurally high block is a topographically low area. Displacement along the fault has been scissorslike. Very slight at the extreme northern end of the range, its stratigraphic value increases southward so that within about 8 miles it is close to 8000 feet. There have been at least two periods of movement along this fault. One was prior to and the other followed the extrusion of Miocene (?) volcanics which are present at the northern end of Fenner Valley.

STEREOSCOPIC STUDY OF AERIAL PHOTOGRAPHS BY BICOLOR PROJECTION

BY STEWART M. JONES †

Classics in geologic interpretation of stereoscopic aerial photographs are small because each student, studying a different set of prints, must have a large share of the instructor's individual attention. The author has found, by making a pair of lantern slides of any pair of overlapping prints and projecting each through a red and green filter respectively as superimposed images upon a screen, that the full stereoscopic effect of the pictures is attained by viewing the screen through spectacles whose lenses are respectively red and green. A large group of students wearing red and green spectacles can be instructed in the physiography and structure of a single area simultaneously by this method of visual instruction.

ROCK CYCLE

BY AUGUSTUS LOCKE

The continental crust is customarily thought to consist of two portions: (1) rocks developed serially from materials once exposed at the surface; and (2) welded into these, igneous rocks of deep origin.

Portion (1) has passed through a cycle of changes including separation into sandstone, shale, and limestone; burial; metamorphism; re-exposure at the surface; and renewed weathering and differentiation.

Granite, constituting most of portion (2), has in geologic usage been separated from the older rocks by the most profound disconformity of origin conceived in petrology. However, the identification of large granite bodies as replacements of schist draws such granite into the metamorphic series and makes it an integral part of the rock

* Introduced by James Gilluly.
† Introduced by Ira S. Allison.

cycle. We are bound, therefore, to think through various concepts in the light of granite as a metamorphic rock.

In this cycle, the principal differentiation of materials is made by weathering, erosion, and transportation, and salic material for the continents is provided by residual concentration. Stuff for growth of the continents is supplied by floods of basic lava ascending through the crust.

Eventually, the rock cycle, as in the Canadian Shield, comes to a stop, and the resulting block acts as a mechanical unit. This stage coincides with the strengthening of weak parts by the growth within them of the large, interlocking hard crystals which constitute granitic rocks.

DEVELOPMENT OF SAN FRANCISCO BAY

BY GEORGE D. LOUDERBACK

In accordance with the general belief, the basin in which San Francisco Bay has developed is considered to be primarily of diastrophic origin, but not to have the close relationship to certain fault blocks that has often been stated. Data obtained within recent years are consistent with a course of the main Sacramento-San Joaquin drainage through the Carquinez and Golden Gate gorges before the advent of the bay, with a gradient through the present bay region of somewhat less than 9 feet per mile. The main tributary from the south appears to have come in on a lower gradient. The southern part of the bay region appears to have had a deformational history, the details of which are not known, but relatively thick deposits of probably early Pleistocene alluvium seem to have been built up in a subsiding basin. The drainage lines of that time are at present purely hypothetical. Suggestive evidence is presented for a theory that the bay was formed chiefly by the elevation of sea level as a result of deglaciation in the late Pleistocene. The open V-shaped valleys in bedrock shown by bore holes indicate that the flooding of the valleys ended a period of downcutting in many of the streams.

GEOLOGY OF DAM SITES ALONG THE WESTERN CASCADE MOUNTAIN FRONT IN WASHINGTON

BY J. HOOVER MACKIN*

Valleys along the western Cascade front in Washington were invaded by tongues of the Puget glacier during the Pleistocene. Each major valley contains one or more narrow segments, often cut in rock, and flanked by deeply filled preglacial valleys. Each gorge segment opens upvalley into a wide valley segment, thus making possible the development of a reservoir of relatively large capacity by a dam of short crest length. Such sites have been utilized, or are now being developed, for dams.

The dam sites are of two types. In one, the fill is a terminal moraine, and the stream was superposed on rock of the preglacial valley side, or, in some instances, was diverted across a divide into a neighboring valley. In the second type the trunk valley was occupied by a lake during a recession, the lake was bisected by a side stream delta, and the trunk stream was superposed from the deltaic sediments. Each type is described: (1) the City of Seattle development on the Cedar River, and (2) the Puget Sound Power and Light development at Snoqualmie Falls.

Cedar Lake is a natural water body impounded by a Puget terminal moraine, now outletting through a narrow gorge cut partly in fill and partly in rock spurs

* Introduced by G. E. Goodspeed.

of the south side of the preglacial Cedar valley. In 1914 the City of Seattle erected a concrete dam in a rock-walled segment of the Cedar gorge. Leakage through the glacial fill flooded a small town in 1915, and there was a great outburst of water from the morainal embankment in 1918.

LOW-ANGLE THRUSTING IN THE ROBERTS MOUNTAINS, NEVADA

BY C. W. MERRIAM AND C. A. ANDERSON

In the Roberts Mountains of central Nevada there is a continuous sequence of rocks ranging from lower Ordovician to Devonian. The Ordovician rocks consist of the Pogonip limestone, Eureka quartzite, and Hanson Creek limestone and shaly limestone. Resting on these rocks with a marked angular discordance and separated by a breccia zone is a low-angle thrust plate consisting of quartzites, calcareous sandstones, cherty shales, cherts, and andesite flows and tuffs (Vinini formation). Numerous graptolite localities date the Vinini formation also as Ordovician. Axial planes of overturned folds in the thrust plate dip southwest suggesting that the thrust plate moved northeast. Confirmation of this is obtained from the distribution of the Ordovician rocks in Nevada for it is only to the southwest of the Roberts Mountains that graptolitic faunas have been found in Ordovician rocks. To the north, east, and south of the Roberts Mountains, the lithology and faunas of the Ordovician rocks are similar to those underneath the thrust plate. There is a minimum horizontal displacement of at least 16 miles. The date of the thrusting is uncertain, but presumably it took place in late Mesozoic or early Tertiary time. Following the thrusting, Tertiary lava flows and tuffs covered the area in part. The thrust plate and cover of volcanic rocks have been broken into normal fault blocks with a maximum throw of at least 1500 feet. (Geological Society project.)

VALENTINITE CRYSTALS

BY JOSEPH MURDOCH

Valentinite crystals from Lone Tree Canyon, Kern County, California, show such an unusual habit that their identity has needed confirmation by chemical, optical, and X-ray tests. The individuals are lathlike in aspect, bounded by a broad and elongated base, a narrow side pinacoid, and a series of prisms, many of which are line faces. Forms present are: *m* (110), *E* (760), *H* (14.9.0), *J* (530), *F* (430), *D* (10.9.0), the new prisms (560), (670), (780), (890), (750), and the pinacoids *c* (001) and *b* (010).

MORENO SHALE, PANOCHE HILLS, FRESNO COUNTY, CALIFORNIA*

BY MAX B. PAYNE†

Detailed mapping of the Moreno formation of Cretaceous and questionable Paleocene age in its type area allows its subdivision into several members. The type localities of these members have been selected in "Escarpado" Canyon. (The mouth of this eastward-draining canyon is near the center of the S½ NW¼ sec. 9, T. 15 S., R. 12 E.) Summarized, these cartographic units, from the stratigraphically highest to the lowest, are as follows:

Dos Palos shale member (disconformably underlying Paleocene glauconitic sandstone). The Dos Palos is 1045 feet thick, consists principally of brown shale, but locally includes the 60-foot Cima sandstone lens 185 feet below its top.

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† Introduced by H. G. Schenck.

Marca shale member: 300 feet of white-weathering, calcareous shale with abundant *Siphogenerinoides*.

Tierra Loma shale member: 1200 feet thick, principally brown shale, but includes the Mercy sandstone lens south and north(?) of Panoche Hills. The Mercy lentil occurs 70 feet below the top of the Tierra Loma and is 190 feet thick near the center of sec. 15, T. 16 S., R. 12 E.

Dosados sand and shale member: 200 feet thick, lying conformably above the Panoche formation, the upper 65 feet of which is here concretionary sandstone.

These members of the Moreno shale have been mapped as lithogenetic units for a distance of 35 miles. On the basis of this mapping, it is concluded that Anderson and Pack (1915) show the base of the Moreno formation in Ortigalita Creek some 1800 feet stratigraphically lower than their type Moreno in Moreno Gulch.

GEOLOGY OF THE POST-PALEOZOIC SURFACE OF THE NORTHERN GREAT PLAINS

BY E. S. PERRY AND L. L. SLOSS

Data from newly studied surface exposures and recently drilled deep wells make it possible to construct geologic cross sections and an areal geologic map of the post-Paleozoic erosion surface of the northern Great Plains as it appeared prior to Mesozoic deposition and diastrophism. Interpretation of the map and cross sections indicates the presence of two positive elements in the area studied: (1) the Sweetgrass Arch, in northern Montana, southern Alberta, and southwestern Saskatchewan; and (2) in southern Wyoming and northern Colorado. The positive elements have previously been recognized, but these new data more closely delineate the areas and time involved. Between the domal areas a low area is shown to have extended eastward from the Cordilleran trough to connect with a basin occupying the western Dakotas. Isopach maps of middle and upper Paleozoic formations indicate that the positive and negative areas persisted throughout the latter part of Paleozoic time in a manner strikingly similar to the Nashville Dome and other elements west of the Appalachian trough.

The exposure of the Madison limestones (lower Mississippian) to erosion and the accompanying development of a solution topography prior to the deposition of the Ellis shales (Jurassic) are important factors in the development of petroleum reservoir conditions in northern Montana and southern Alberta. The map indicates the area over which such conditions may be found and the areas where other potential reservoir rocks have been truncated by the erosion surface. Furthermore, the similarity of the basin area in the western Dakotas to the Illinois and Michigan basins is noteworthy in view of the oil production in those areas.

ORIGIN OF THE TRABUCO CONGLOMERATE, SOUTHERN CALIFORNIA

BY WILLIS PARKISON POPENOE*

A thick conglomerate series in the Santa Ana Mountains, southern California, unconformably overlies Triassic metamorphics and Jura-Cretaceous intrusives and probably conformably underlies marine early Upper Cretaceous sandstones. The lower 400-500 feet of this series is deeply weathered, red, soft, massive; the upper 100 feet is fresh, greenish-gray to brown, resistant, thick-bedded, and probably marine. The red lower part, named the Trabuco formation by E. L. Packard, was

* Introduced by Ian Campbell.

interpreted as a continental deposit older than the overlying gray conglomerate, and by Bernard Moore as a marine deposit continuous with and genetically inseparable from the gray conglomerate but weathered to its present condition by circulating iron-bearing meteoric waters active after the deposition of the entire conglomerate series.

Field studies of the conglomerates and pebble counts made at a number of stratigraphic levels and localities along the strike show that the upper and lower conglomerates are probably conformable and have no constant differences in composition, size, or rounding of the included pebbles. The marked and constant differences in color, topographic expression, and consolidation are believed due to differences in weathering. The Trabuco conglomerate is interpreted as a flood-plain deposit weathered deeply in place before deposition of the gray marine conglomerate overlying. The Trabuco conglomerate is thus recognized as a valid formation, confirming Packard's original interpretation.

METAMORPHISM OF DOLOMITE NEAR RIVERSIDE, WASHINGTON

BY FRED B. ROBERTS *

On Johnson Creek near Riverside, Washington, beds of dolomite have been metamorphosed by the emplacement of two bodies—a primary gneiss and a granite. The effects of their emplacement on the carbonate rock can be divided into two stages: In the first stage thermal metamorphism produced "dedolomitization," resulting in the formation of forsterite, tremolite, diopside, and calcite. The most important control for this change was variation in the magnesia and silica content of the original carbonate rocks. One rock type, composed of over 90 per cent of forsterite and antigorite, may have been derived from magnesite. In the second stage of lower temperature hydrothermal alteration silica and water were added to the rocks changing the thermal metamorphic minerals, in part, into antigorite-carbonate rocks, or "ophicalcites." Also associated with this stage are quartz veins which cut across all the rocks and are probably the last phase of the hydrothermal process. Talcose rocks were developed along shear zones.

TRACHYTOID NEPHELINE SYENITE FROM LINCOLN COUNTY, OREGON

BY AUSTIN F. ROGERS, HENRY V. HOWE, AND LLOYD W. STAPLES

A prominent landmark known as Table Mountain in the Siuslaw National Forest of Lincoln County, Oregon, and about 15 miles southeast of Newport, consists largely of a small intrusive mass of nepheline syenite. This was identified by Howe some years ago and has been confirmed by petrographic study of an extensive suite of specimens and a chemical analysis of one of them.

The rock is a nepheline syenite showing trachytoid texture with prominent phenocrysts of nepheline in a groundmass of albite. Other minerals are aegirine, aegirine-augite, riebeckite, a dark-brown amphibole, deuteric analcime, and minor accessories. The specimens show little variation in either mineralogy or texture.

The nepheline syenite occurs in an area of sandstone, probably the middle Eocene Tyee formation. The age of the intrusion is tentatively given as post-middle Eocene.

* Introduced by A. C. Waters.

GEOLOGY AND PHYSIOGRAPHY OF THE NORTHERN WALLOWA MOUNTAINS, OREGON*

BY WARREN DUPRE SMITH AND JOHN ELIOT ALLEN

The Wallowa Mountains of northeastern Oregon rise to an elevation of 10,000 feet. Greenish lavas, tuffs, and sediments of probable Permian age are the oldest rocks, from 3000 to 5000 feet in thickness. A thick sequence of altered upper Triassic sediments overlies the greenstones. The lower series of shales and hornfels (2000 feet thick) is followed upward by 2000 to 3000 feet of the Martin Bridge formation, largely crystalline limestone, and the upper Hurwal formation made up of 1000 to 3000 feet of shales and sandstones.

These rocks were extensively folded and intruded in middle Mesozoic time by batholithic masses of granodiorite.

Erosion during Cretaceous and early Tertiary times stripped off much of the cover overlying the granodiorite and reduced the mountains to a rolling plain.

Basalts correlated with the Columbia River lava flood were extruded from north-south cracks in the crust during the middle Tertiary and apparently covered the entire area. Remnants of lava today cap the crests of some of the highest peaks in the range. Faulting occurred in the late Tertiary and was most pronounced along the northern front of the mountains. The range was elevated at this time to its present average height of over 8000 feet. Deep, radial valleys were developed, which were widened and deepened during the Pleistocene by the glaciers coming down them from the ice cap that covered the center of the area.

DUCKBILL DINOSAUR FROM THE MORENO CRETACEOUS, CALIFORNIA

BY CHESTER STOCK

A skull and the greater portion of an associated skeleton of a duckbill dinosaur were discovered in the Moreno Cretaceous of the Tumey Hills, western Fresno County, by the California Institute of Technology in 1940. The specimen is flattened, and some skeletal parts are missing. Only the skull has been prepared so far. The stratigraphic position of this dinosaur in the Moreno is estimated to be approximately 150 feet below the base of the *Siphogenerinoides* zone by Max Payne. In correlated deposits of the Panoche Hills occur remains of plesiosaurs and mosasaurs.

The skull represents a member of the subfamily Hadrosaurinae. Relationship of the Californian species is with the hadrosaurs of the Lance, Edmonton, and Judith River of the western Great Plains and Rocky Mountains.

PRELIMINARY DESCRIPTION OF THE FRESNILLO DISTRICT, ZACATECAS, MEXICO

BY J. B. STONE

The Fresnillo district lying near the western edge of the Mexican Plateau is one of the world's largest silver producers, but there is no modern geological description. This paper is based on recent economic geological studies of the now extensive mine workings.

The oldest rocks are the Mesozoic (?) Proaño group of graywacke, shale, and subordinate limestone and have a thickness of more than 1000 meters. They are probably Middle Cretaceous or older. During the Laramide Revolution (?) the Proaño group was folded along an anticlinal axis trending west-northwest. A surface

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of considerable relief was then developed, unlike the early Tertiary peneplane sometimes postulated for the Mexican Plateau.

Lying above this erosion surface are successively a thick deposit of sedimentary breccia, Tertiary (?) tuffaceous sediments containing abundant andesite fragments, Tertiary (?) rhyolites, and finally latite and basalt flows. The rhyolite flows and older post-Mesozoic (?) rocks are tilted but not faulted. Elsewhere in the region they are cut by large normal faults.

No intrusive rocks are known at Fresnillo, but near by at Plateros a small stock of granodiorite is intruded into the Proaño group. The veins of Fresnillo and Plateros are younger than the granodiorite and probably younger than the Tertiary (?) rhyolites. The veins contain chiefly pyrite, marmatite, galena, and chalcopyrite with minor pyrrhotite, arsenopyrite, and pyrargyrite. They fall in Graton's leptothermal class. An unusual feature is the local occurrence of abundant axinite. The veins follow persistent fractures of small displacement, striking generally northwest.

CORRELATION OF THE JURASSIC OF SOUTHWESTERN OREGON AND CALIFORNIA

BY N. L. TALIAFERRO

The generally accepted correlations of the Jurassic of southwestern Oregon and California are as follows: Galice and Mariposa, Dothan and Franciscan, Myrtle and Shasta. The Dothan is stated to be younger than the Galice. On the other hand it has been stated that the Dillard, the lower part of the original Myrtle, is the equivalent of the Franciscan. Since the Dillard unconformably overlies Dothan and Galice, it is clear that one or the other of these correlations must be erroneous. Evidence is presented to show that the Dothan is older than the Galice and cannot be of the same age as the Franciscan. The Dillard, as originally defined, includes Knoxville (Upper Jurassic) sediments and possibly infolded Lower Cretaceous, but the great bulk of the Dillard is to be correlated with the Franciscan. The Myrtle, as mapped and defined, includes beds of both Upper Jurassic and Lower Cretaceous age and at least one important unconformity; the Myrtle either should be redefined and restricted or the name abandoned.

The Nevadan orogeny took place in the late Kimmeridgian and uplifted the Sierra Nevada and depressed the belt now occupied by the Coast Ranges. In the geosyncline thus formed the Franciscan and Knoxville were deposited. There is no unconformity between the Franciscan and Knoxville; these groups were deposited during the Portlandian and Tithonian.

There is a widespread unconformity at the base of the Lower Cretaceous. The diastrophism which closed the Jurassic is called the Diablan orogeny.

VAQUEROS FORMATION (TERTIARY) AT ITS TYPE LOCALITY, JUNIPERO SERRA QUADRANGLE, MONTEREY COUNTY, CALIFORNIA

BY RICHARD R. THORUP *

The Vaqueros formation was named by Hamlin (1904) for a sequence of sandstones occurring in Los Vaqueros Valley between the basement complex and the Monterey shale. The present writer has mapped in detail 13 cartographic units between the basement complex and the Monterey shale in this area. The following restricted

* Introduced by H. G. Schenck.

definition of the Vaqueros formation agrees with established usage; five other distinctive units are given new formational names.

MONTEREY SHALE	Uppermost formation mapped. Lower argillaceous shales and sandstones of former definitions excluded.
SANDHOLDT FORMATION	Member C. Clay shales and calcareous shales; Relizian Foraminifera; 500± feet. Member B. Sandstone; 50± feet. Member A. Shale, some sandstone; Saucesian Foraminifera; 250± feet. Type Locality: N½ and SE¼ sec. 14, NE¼ sec. 15, T. 20 S. R. 6 E.
VAQUEROS FORMATION (RESTRICTED)	Member F. Sandstone and siltstone; 500-600 feet. Member E. Massive sandstone, some shale; 500± feet. Member D. Fine sandstone, siltstone; 70-150 feet. Member C. Coarse gray sandstone; 250-400 feet. Member B. Tan sandstone and shale; 180-350 feet. Member A. Sandstone with "Dosinia reef", grades downward into conglomerate; 200± feet.
BERRY CONGLOMERATE	Continental. Type Locality: SE¼ sec. 26, T. 20 S., R. 6 E. Thickness 1100 feet ±. Disconformity at base.
THE ROCKS SANDSTONE	Type Locality: Sec. 27. T. 20 S. R. 6 E. Thickness 1500± feet.
LUCIA SHALE	Type Locality: NE¼ sec. 34, N½ sec. 35, SE¼ sec. 26, T. 20 S., R. 6 E. Thickness 100-500 feet. Abundant Eocene Foraminifera.
JUNIPERO SANDSTONE	Type Locality: NE¼ sec. 34, T. 20 S., R. 6 E. Thickness 0-125 feet. Eocene (?). Unconformable on basement complex.

COLLAPSED VESICLES, ALTERATION BANDING, AND PLATY JOINTING OF BASALT

BY A. C. WATERS

Flows of the Columbia River basalt in eastern Washington and adjacent parts of Oregon and Idaho are commonly more than 50 feet thick and nearly always show excellent columnar jointing.

In the thicker flows horizontal zones are sometimes found along which a well-developed platy jointing has cross-sectioned the basalt columns into thin sheets. Thin sections across these plates show that the platy jointing develops along very thin diktytaxitic bands intercalated with much thicker bands showing the ordinary intergranular or intersertal textures characteristic of the basalts of this region. Traced upward in the flow the diktytaxitic bands lose their medial joint, become less continuous, and then break up into pancakelike patches of open-textured rock, which give way in turn to collapsed and greatly elongated vesicles with indefinite boundaries. Higher in the flow the vesicles assume lenslike shapes with amoebaform and diktytaxitic extensions and ultimately give way to spherical bubbles with sharp boundaries.

Slight deuteric alteration is common along the collapsed vesicles and diktytaxitic layers and gives the rock a smeary type of banding even where the platy joints are not developed.

The flattened vesicles and attenuated diktytaxitic bands are not flow structures formed during the advance of the flow. This is proved by the fact that definite flow banding, shown by aligned microphenocrysts and microlites, is often cut at an angle by diktytaxitic bands. Furthermore the platy joints are younger than the columnar joints.

GUALALA SERIES AND MIOCENE BEDS, MENDOCINO COUNTY, CALIFORNIA

BY CHARLES E. WEAVER

Excellent exposures of Cretaceous and Miocene sedimentary rocks occur in the sea cliffs between Fort Ross and Point Arena Lighthouse in Mendocino County. They are separated from the Franciscan rocks farther east by the San Andreas fault.

The Gualala series of upper Cretaceous age is approximately 20,000 feet thick and consists prevailingly of massive and stratified brownish-gray medium- to coarse-grained quartzose sandstones which often become gritty and pebbly and locally contain lenses of conglomerate. The conglomerates are especially abundant near the base and middle of the series. There are also thick layers of clay shale. Interstratified shaly sandstones and sandy shales constitute 30 per cent of the entire stratigraphic section. These beds lie in two major synclinal and two anticlinal folds whose axes trend diagonally to the course of the San Andreas fault. Fossils are few and poorly preserved.

The Miocene beds occupy an area 7 miles long south of Point Arena lighthouse and consist of about 5000 feet of sediments the lower half of which are mainly stratified shaly sandstones and foraminiferal shales and the upper half badly contorted thinly laminated siliceous shales and cherts with interbedded sandy shales, all sharply folded. Some of the sandstones contain residues of petroleum. Submarine basaltic flows lie unconformably upon Cretaceous and disconformably beneath Miocene deposits. All of these formations have been folded, faulted, uplifted, and beveled by erosion to a plain now from 30 to 60 feet above sea level. Upon it rests from 25 to 50 feet of Pleistocene terrace deposits.

LOWER AND MIDDLE CAMBRIAN CORRELATIONS IN NEVADA AND ARIZONA*

BY HARRY E. WHEELER †

Biostratigraphic and lithologic correlations of Lower and Middle Cambrian strata are made in eastern and southeastern Nevada: at Eureka, Cave Valley, Pioche, Delamar, Mormon Range, and Virgin Mountains; and in Arizona: at the western end of the Grand Canyon near Grand Wash Cliffs and in the Granite Gorge area of the Canyon.

These correlations, made at average intervals of about 55 miles, disclose widespread faunal and lithologic continuity in that portion of the Cordilleran geosyncline and thus permit unification and consequent simplification of formational nomenclature.

The Prospect Mountain quartzite (Eureka district) is present throughout the entire region, varying in age from late Algonkian (?) and Early Cambrian in the north and west (Eureka) to early Medial Cambrian in the southeast (Granite Gorge area), where it has been designated "Tapeats sandstone" (Noble, 1914). The overlying Pioche shale (Pioche district) is recognized from Eureka to the western Grand Canyon. The Pioche formation is Lower Cambrian (*Olenellus* zone) at Eureka,

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† Introduced by Hubert G. Schenck.

and both Lower and Middle Cambrian (*Olenellus* to *Albertella* zones) from Pioche southward. The Middle Cambrian Lyndon limestone and Chisholm shale (both of the Pioche district) may be traced northward to Cave Valley and southward to the western Grand Canyon, with the latter formation carrying the *Zacanthoides-Anoria* fauna, or the *Glossopleura* fauna, or both.

The combined Pioche, Lyndon, and Chisholm formations constitute the lithogenetic counterpart of the Bright Angel shale (Granite Gorge). The Middle Cambrian Muav limestone (Granite Gorge) is present at all localities as far north as Cave Valley. At Pioche the Muav formation has been called "Peasley limestone" (Wheeler, 1940). All above-mentioned Cambrian strata are conformable.

STRUCTURAL HISTORY OF THE SAN BENITO QUADRANGLE, CALIFORNIA

BY IVAN F. WILSON *

This area embraces parts of the Gabilan and Diablo ranges, separated by the San Andreas fault zone. The Gabilan Range, to the southwest, consists of a granite basement overlain by Middle (?) and Upper Miocene volcanics and sediments.

The Diablo Range here comprises two stratigraphic belts of post-Franciscan rocks overlying a Franciscan basement. The eastern belt is a syncline with a great thickness of Upper Cretaceous, Middle and Upper Eocene, and Middle Miocene marine sediments. This is part of a former seaway extending east through the Vallecitos syncline to the San Joaquin Valley. It was strongly folded between the Middle Miocene and Middle Pliocene.

Between this syncline and the San Andreas fault zone is a narrow belt, 2 to 3 miles wide, of Upper Miocene and Pliocene marine sediments, deposited in a seaway connected with the San Joaquin Valley through Waltham Canyon to the southeast. This was strongly folded and thrust-faulted during the Upper Pliocene. The marine Pliocene overlaps the western part of the older syncline, but farther east only nonmarine Pliocene occurs.

Much of the entire area was blanketed by Plio-Pleistocene continental sediments. In the late Pleistocene these were gently folded and faulted, in part by reversal of movement on some of the older thrust faults.

Here the San Andreas is a fault showing recent horizontal movement. In part it follows, in part diverges half a mile from an older fault separating the granite and Franciscan basements.

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* Introduced by N. L. Taliaferro.

ABSTRACTS OF THE PALEONTOLOGICAL SOCIETY

DECEMBER MEETING AT BOSTON

LOWER PALEOZOIC TETRACORAL FAMILY COLUMNARIIDAE

BY R. S. BASSLER

Since the uncertainty regarding the genotypes of many rugose coral (Tetracoralla) genera has been removed by the publication in 1940 of the Index of Paleozoic Coral Genera by Lang, Smith, and Thomas, research upon this group can now proceed upon a firm basis. Many of the older Tetracoralla have been assigned to the Cyathophyllidae, characterized mainly by radially arranged septa, although other family names have been proposed for special sections of this one and then abandoned as synonyms. The discovery that the oldest known compound coral, *Tetradium simplex* Bassler, from the Ozarkian rocks of Maryland, is a *Lichenaria* exhibiting the simplest type of structure in the Columnariidae, a family long ago separated from the Cyathophyllidae by Nicholson, suggests the following evolutionary trend. *Lichenaria* with tabulae but without septa gives rise to *Lyopora* and also to *Nyctopora*, the latter with the septa forming strongly crenulated walls. From it is derived also a group of species here designated as *Foerstephyllum*, new genus, characterized by tabulae and very short straight septa, with *Columnaria halli* Nicholson as the genotype. From *Foerstephyllum* arises the genus *Favistella* Hall long considered a synonym of *Columnaria* but marked by septa reaching nearly to the center. In the Richmond group, *Favistella*-like forms lead to the genus *Paleophyllum* with separated corallites and then by the addition of dissepiments culminate in the Silurian and Devonian in typical *Columnaria*. In the Silurian occur the interesting *Stauria*, with four distinct septa meeting at the center, and other genera whose characteristics are not yet clearly understood. For *Lyopora* which seems to be a *Lichenaria* with very thick walls a distinct family was recognized by Kiaer in 1932, as was one also later for *Lichenaria* itself, thus bringing up questions of family priority.

LARGER FORAMINIFERA FROM THE TERTIARY OF PUERTO RICO

BY ELEANOR T. CALDWELL

Larger Foraminifera are very abundant in parts of the marine Tertiary formations of Puerto Rico where their presence in such great abundance is indicative of shallow, warm-water deposition. Twenty species and varieties, four of which are new, are identified and described from four of these formations—namely, the Juana Diaz and Ponce formations of the south shore and the San Sebastian and Cibao formations of the north shore. The ages assigned by Meyerhoff in 1933 were as follows: San Sebastian, middle Oligocene; Cibao, upper Oligocene; Juana Diaz, middle Oligocene; Ponce, Upper Oligocene to lower Miocene. Ponce localities in this study represent only the lower part of the Ponce formation.

Three families of larger Foraminifera are represented in these formations: 1 species of Soritidae, 2 genera and 4 species of Camerinidae, and 13 species of *Lepidocyclina*, the only genus of Orbitoididae found.

The Ponce formation is characterized by a great abundance of *Lepidocyclina*, particularly *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman and *Lepidocyclina* (*Eulepidina*) *undosa* Cushman. The San Sebastian and Cibao formations contain great numbers of *Heterostegina*, and one species of Soritidae is common in the San Sebastian.

All species of larger Foraminifera found in Puerto Rico, with the exception of new species and varieties, occur elsewhere in the West Indian and Gulf regions in Tertiary beds of known age. With the exception of one or possibly two species, these larger *Foraminifera* are restricted to the middle and upper Oligocene.

MIOCENE RADIOLARIAN FAUNAS FROM SOUTHERN CALIFORNIA

BY ARTHUR S. CAMPBELL AND BRUCE L. CLARK

A number of shale samples from the Miocene of the Palos Verdes Hills and from the Newport Bay area, Southern California, were given to the writers by the late Dr. R. D. Reed. In this material were found numerous very well-preserved Radiolaria, the total number of species of which is 91. All of these have been described by the writers as new. It is the largest and best-preserved assemblage of Radiolaria that has been described from beds of Miocene age in North America. The samples in the Palos Verdes Hills came from two major zones in the Monterey shales, as recognized by Woodring, Bramlette, and Kleinpell in 1936. The lower of the two radiolarian zones comes in the Valmonte diatomite, while the upper zone comes in the Malago mudstone.

The radiolarian assemblages from the Newport Bay area are more like those found in the Valmonte diatomite than those from the Malago mudstones. The paper, besides describing the species, discusses the probable ecological conditions that existed during the deposition of the Valmonte diatomites and the Malago mudstones. (Geological Society project.)

LAOTIROID, PENTALOBATE IMPRESSION FROM THE UPPER CAMBRIAN OF WYOMING

BY KENNETH E. CASTER

A Problematicum from the Upper Cambrian (Boysen formation) in the Wind River Canyon of Wyoming appears to be the strand imprint of the same type of organism represented by *Laotira cambria* Walcott, a supposed jellyfish, from the Middle Cambrian of Alabama. The conditions of preservation, as well as the general plan, strongly suggest that the Wyoming impression is that of a medusoid, although other possibilities are suggested by the pentaradial symmetry and apparent turgidity or solidity of the body at the time the mold was made. The specimen will be available.

TITUSVILLIIDAE: USEFUL STRATIGRAPHIC INDICES

BY KENNETH E. CASTER

The species or form variants of the branching siliceous sponges *Protoarmstrongia, Armstrongia,* and *Titusvillia,* which range through the Upper Devonian from the Senecan series into the basal Mississippian of the Penn-York Embayment, have proved to be such useful indices that wider search for them seems desirable. To one seeing the sponges in the field for the first time they seem to be either mud cracks or enigmatic worm burrows of nodose plan and consequently have almost escaped the attention of paleontologists. If the family is still represented in Philippine waters by the branching *Sclerothamnus,* as was recently proposed, the chances seem very good for finding fossil representatives through an enormous vertical and horizontal range, or at least for as long as they inhabited waters shallow enough to be represented by epeiric deposits. Typical representatives of the three genera of fossils, including some types, will be exhibited.

UPPER EOCENE FAUNA FROM COLOMBIA, SOUTH AMERICA

BY BRUCE L. CLARK

The author has recently studied well-preserved collections from the Tertiary deposits of the Department of Bolivar, Colombia. All of these came from about the same zone. The fauna includes about 75 molluscan species, a large proportion of which are new, and a number of corals and Foraminifera. One of the coral species has been determined as very close, if not identical to, *Syzgophyllia hayesi* Vaughan from beds of upper Eocene age in Nicaragua. Associated with this is *Lepidocyclina (Pliolepidina) tobleri* Douvillé, described from deposits referred to upper Eocene in Trinidad and reported from several other localities in upper Eocene deposits of the Caribbean region.

Several of the described molluscan species of this fauna are found in the Claiborne and Jackson Eocene of the Southern United States; several are also close to species found in the upper Eocene of Western North America.

By far the largest number of described species in this fauna is reported by A. A. Olsson from Peru from deposits referred by him to the upper Eocene and lower Oligocene. The conclusion is that this Columbian fauna is upper Eocene in age.

A majority of the species and a number of the genera of this upper Eocene fauna have not been found in any other province. This points to a considerable degree of isolation. A number of the mollusks belong to genera which have previously been known only from deposits later than Eocene. Among these are such genera as *Anadara, Amiantis, Astraea, Chione,* and *Compsomyax.*

STUDY AND REVISION OF ARCHIMEDES

BY G. E. CONDRA AND M. K. ELIAS

Detailed morphologic and anatomic investigation indicates a compound nature of the fossil known as *Archimedes. Archimedes* screws usually develop upon the outer edges of *Fenestella* zoaria and are made of the extended coiled meshwork of this Bryozoa encrusted in the axis of the coiling by a protean organism, apparently an epizoic alga. The two symbionts formed intimate organic consortium, seemingly beneficial for both.

All species of *Fenestella* discovered as *Archimedes* symbionts were also found to form independent, noncoiled zoaria. Nine of these species are newly described.

Nearly all species of *Archimedes* previously known and 19 new American and Russian species are described and illustrated in some detail.

In America *Archimedes* ranges from Lower Devonian (Falls of Ohio River) to Lower Pennsylvanian (Utah), while in Russia it is found only in Upper Carboniferous and Lower Permian.

In the Lower Devonian only the loosely coiled *Archimedes* (called *Helicopora* by Claypole) is known, while in the other, younger rocks both loosely coiled and tightly coiled zoaria, with heavy central screw, are well represented. (Geological Society project.)

MIDDLE ORDOVICIAN OF THE CHAMBERSBURG REGION, PENNSYLVANIA

BY LAWRENCE C. CRAIG

The Chambersburg limestone is divided into three formations with their type sections 2 miles southwest of Marion, Pennsylvania. The Shippensburg formation (new) overlies the "Lowville" of Butts and Stose (1932) and consists of 500 feet

of dark-gray limestone, cobbly below and even-bedded above. The Mercersburg formation (new) is 150 feet of dark-gray, thin irregular and thick even-bedded limestone with the base at the bottom of a drab cuneiform siltstone zone containing a metabentonite. The overlying Greencastle formation (Bassler) is 63+ feet of black massive limestone, locally with a thin basal calcarenyte. The Greencastle includes the *Sinuites* zone at the top and is overlain by Martinsburg shale.

The Shippensburg formation thins westward from Marion to extinction along Cove and North Mountains. In the western belts of outcrop in the Cumberland Valley the Mercersburg and Greencastle converge, the former being separated from the Shippensburg by the Hatter limestone and the Snyder member of the Benner limestone (Kay). From Path Valley, the Hatter and Snyder thin southeastward to extinction between the Williamson and Chambersburg outcrop belts. A southward-trending structural axis passing from Path Valley through western belts of the Cumberland Valley is evidenced in the westward extinction of the Shippensburg, eastward extinction of the Hatter and Snyder, and westward convergence of the Mercersburg and Greencastle. The Shippensburg is pre-Pamelia, if the Benner is of Pamelia age. The Mercersburg and Greencastle correspond to the Rockland Hull and lower Salona of Central Pennsylvania.

ORIENTATIONS AND SYMMETRIES IN THE ECHINODERMA

BY CAREY CRONEIS

The orientation of larval blastoids adopted by Croneis and Geis, and criticized by Moore, is defended. The various ramifications of the problem of orientation of the blastoids are outlined, and associated anomalies involved in the symmetries of pelmatozoans, in contrast to those of the eleutherozoans, are also discussed. Some of the hurdles which must be cleared before arriving at a concise and uniform system of orientation for all echinoderms are pointed out, and suggestions for future procedure are advanced.

TRIANGULAR COILING IN THE CEPHALOPODA

BY CAREY CRONEIS AND RUTH HOPE YOUNG

Triangular coiling in the Cephalopoda is a little known aberrancy apparently confined to a relatively few Paleozoic representatives of the class. The phenomenon, however, has a widespread geographic representation involving occurrences in areas as widely separated as Germany and Texas, and a geological range at least as extended as from the late Devonian to the early Pennsylvanian.

In this paper the various examples of triangular coiling are described and compared, and the relatively obscure literature on the subject is reviewed. Earlier theories advanced to account for the phenomenon are examined, and a genetic concept, which may have applicability in other paleontologic problems, is offered as a possible explanation.

CAMBRIAN GRAPTOLITES FROM WISCONSIN

BY CHARLES E. DECKER

In August 1941 the writer made collections from two of the six known Cambrian graptolite localities of Wisconsin.

From northeast of Spring Green, southwestern Sauk County, only the basal part of a *Dictyonema* had been secured, while the recent collection yielded *Dendrograptus thomasi, D. hallianus, D. hallianus spissus, D.* cf. *edwardsi, D. n. sp., Callograptus*

staufferi, C. sp., Mastigograptus, possibly a small fragment of an *Acanthograptus,* and a new species of *Dictyonema.*

From west of Ontario in southern Monroe County the following species had been secured: *Dendrograptus hallianus, D. edwardsi,* and *Haplograptus wisconsinensis.* In addition to these three, the recent collection has yielded: *Dendrograptus thomasi, D. edwardsi major, D. hallianus spissus, Callograptus staufferi, C. n. sp., Dictyonema n. sp., Chaunograptus sp., Mastigograptus sp.,* and a new genus, *Haplotoidograptus.*

The species collected recently from the two localities exceed by a considerable number those previously collected from all of the localities in Wisconsin. Furthermore, the geographic distribution of a number of species has been greatly extended. The forms collected, including the new genus and several new species, will be described and illustrated.

PLANTS FROM THE CRETACEOUS MESAVERDE GROUP OF COLORADO AND WYOMING

BY ERLING DORF

Numerous plant remains, chiefly of dicotyledons, palms, and ferns, were obtained at four localities in the Ericson sandstone and Almond formation near Rock Springs, Wyoming. Collections were made in part by Barnum Brown of the American Museum of Natural History and in part by the writer. Late Montanan age of the beds is indicated by the floras. Stratigraphic relations indicate that the beds were deposited in lowlands along the western border of the advancing Montanan sea represented by the Lewis shale above the Almond.

In western Colorado the plant remains were collected at eight localities in the Hunter Canyon formation along Plateau Creek west of Mesa, with the co-operation of Bryan Patterson of the Field Museum. The flora indicates that the Hunter Canyon deposits extend from Montanan time into Lancian time. The absence of the Lewis shale in the section is interpreted to mean that the Montanan sea did not advance into this region.

These studies are being conducted under the joint auspices of the Carnegie Institution of Washington and Princeton University.

NEOTYPES IN NATURAL HISTORY

BY CARL O. DUNBAR

There is a growing tendency on the part of paleontologists to designate neotypes for species of which the original types have been lost or destroyed. The present war, with its indiscriminate destruction, will greatly increase the need of neotypes in all branches of biology. Even this, however, only hastens the inevitable, for in the course of centuries many zoological and botanical types will disintegrate, and some fossils will oxidize and crumble to dust.

At present neotypes have no legal standing, however, for they are not recognized in the International Rules of Zoological Nomenclature or in the International Rules of Botanical Nomenclature. It is now time that provision be made by the appropriate Commissions for the selection of neotypes.

In the past, neotypes have most commonly been proposed for species that are poorly known, chiefly those based on doubtful fragments or those so poorly described that need is felt of a "type" to fix, once and for all, the conception to which the name should be tied. Neotypes should be selected, on the contrary, for species that are so well described that a new type can be chosen that is beyond doubt conspecific.

REVISION OF *CAMPOPHYLLUM* IN NORTH AMERICA

BY WILLIAM H. EASTON

As a result of a revision of the described North American species of *Campophyllum* Edwards and Haime, 1850, several taxonomic changes are suggested. Of the four described Carboniferous species, *Campophyllum ? texanum* Shumard is unrecognizable (as stated by Moore and Jeffords (1941)); *C. kansasense* Miller and Gurley, though caninoid, seemingly belongs to a new genus; *C. gasperense* Butts and *C. torquium* (Owen) are both representatives of *Caninia* Michelin, 1840.

Of the three Devonian species, *C. nanum* Hall and Whitfield is the genotype of *Charactophyllum* Simpson, 1900; specimens first identified by Whiteaves as *Chonophyllum* (*Ptychophyllum*) *ellipticum* Hall and Whitfield but referred to the genus *Campophyllum* and subsequently named *Cyathophyllum McConnelli* [sic] by him were assigned by Fenton and Fenton (1924) to the genus *Tabulophyllum* Fenton and Fenton, 1924, and were considered by them to be closely related to *Tabulophyllum ehlersi* Fenton and Fenton. *"Campophyllum mcconelli* [sic] Whiteaves" exists in the literature as a misquotation of *"Cyathophyllum McConnelli* Whiteaves."

Morphology, ontogeny, and stratigraphic distribution of the Carboniferous species are presented, and the relationships of several genera also are discussed. The writer does not recognize any valid species of *Campophyllum* in North America.

PHYLOGENY OF THE EQUID BRAIN

BY TILLY EDINGER *

The endocranial cast material assembled up to date for this investigation is incomplete; not all genera in the ascendency of the horse are represented, and most specimens at hand give a picture of only part of the brain, or of a distorted brain. Additional material is desired to supplement and check the preliminary observations.

The olfactory bulbs extended from the forebrain floor up to the skull roof in the Eocene. The transverse skull roof septum which sets off their chambers from the forebrain chamber occupies one-eleventh of the skull height in *Eohippus*, one-fourth in *Mesohippus*, but almost one-half in *Equus*. As the bulbs are large too in the still macrosmatic living horse, and the skull profile has remained the same, the increasing pneumatic sinuses developed in this septum after the Eocene seem directly due to the outstanding progressive feature in brain evolution—the expansion of the forebrain. In the ontogeny of the horse, this phylogenetical sinking downward of the olfactory bulbs is reversed; the embryonic forebrain is relatively high, and the growing bulbs extend forward and upward.

Forebrain fissuration is simple, consisting of straight furrows, in the Middle Oligocene *Mesohippus*. The Upper Miocene *Merychippus* displays multibranched tortuous horse type fissures. Intermediate between these two very different types is the still relatively narrow forebrain of the middle Miocene *Parahippus* with branched, slightly curved fissures. Ontogenetical fissure development repeats phylogeny, but a much higher stage of fissuration is reached in the horse embryo than was attained in a horse ancestor of the same skull length. (Geological Society project.)

* Introduced by A. S. Romer.

GENETIC RELATIONSHIPS OF THE DEVONIAN TROCHOCERoid CEPHALOPODS *SPHYRADOCERAS* AND *NAEDYCERAS*

BY ROUSSEAU H. FLOWER

A study of relationships of two trochoceroid genera of the Schoharie grit, Middle Devonian, of New York, opposes the generally accepted view that trochoceroids are benthonic adaptations of nautilicones and gave rise to nothing higher.

The costate *Sphyradoceras* is of uncertain origin, its relationship with the Silurian *Lechritrochoceras* being dubious. Through *Baeopleuroceras* which retains in the adult the nepionic features of *Sphyradoceras,* it gives rise to the Rhadinoceratidae within which two tendencies are evident: (1) an increase in coiling and the development of a nephritic whorl as in *Rhadinoceras,* and (2) reduction in coiling terminating in the straight breviconic *Endoplanoceras.*

The smooth Brevicoceratidae (nov.) are represented by two trochoceroid species groups formerly included in *Naedyceras:* (1) a loose coiled trochoceroid of symmetrical section, and (2) a cyrtocone of eccentric section. These are connected by the Upper Silurian *Mitroceras,* which can be traced back through *Oxygonioceras* to Middle Silurian and even Ordovician cyrtoconic cephalopods. More surprising are the derivatives of the group, which include two groups of gyroceracones and several genera of brevicones.

The evidence upon which these relationships are based is presented. The value of the extensive use of coiling in dividing genera is questioned, and the taxonomic value and morphological significance of actinosiphonate deposits are considered.

RELATIONSHIP OF LATE CRETACEOUS CODY SHALE FORAMINIFERA FROM NORTHERN WYOMING AND SOUTHERN MONTANA TO GREAT PLAINS AND CANADIAN FAUNAS

BY STEVEN K. FOX, JR.

An analysis of 94 species of late Cretaceous Foraminifera from three well-exposed sections of the Cody shale in northern Wyoming and southern Montana indicates (1) 60 calcareous species, 30 arenaceous species, and 4 new species; (2) three faunal zones in the Cody; and (3) correlation of the Cody with the Niobrara chalk of the Great Plains and with the upper part of the Alberta shale of Canada.

The lowest faunal zone in the Cody is dominated by calcareous species such as *Lenticulina kansasensis* Morrow. The species in this zone occur in 200 feet of clay shale. A mixture of arenaceous and calcareous species in sandy shale characterizes the middle zone in the Cody. *Flabellammina compressa* (Beissel) is common throughout the 800 feet of this zone. In the uppermost zone of approximately 175 feet of sandy shale and sandstone, arenaceous species, such as *Haplophragmoides calcula* Cushman and Waters, predominate.

The mixture of calcareous and arenaceous species in the Cody greatly facilitates correlation with the calcareous Niobrara fauna of the Great Plains and with the arenaceous Alberta fauna of Canada. Correlation in each case is based on the number of restricted Niobrara and Alberta forms which occur in the Cody.

Correlation of the entire Cody shale with the Niobrara supports Reeside's conclusions from mollusk evidence but is contrary to the frequent practice of designating the lower Cody as Carlile in age.

RECURRENCE OF MORPHOLOGIC TYPES AND OF EVOLUTIONARY CYCLES IN MESOZOIC AMMONITES

BY OTTO HAAS

Examples of striking resemblances, both in shape and in ornamentation, between forms, or even groups, of ammonites of quite different geological age have long been known. They are not, as Steinmann (1908; 1909) erroneously asserted, due to persistence of races but are merely due to recurrence of morphologic types. It will be shown that, in some cases, even the same differentiation of certain types as to their whorl sections, degree of involution, and character of costation recurs within groups separated by wide chronological intervals. However, not only types and groups of types reiterate themselves in the history of ammonites, but also certain evolutionary cycles, each proceeding along definite anagenetic trends, *e. g.*, from evolute, sturdy forms with coarse and stiff ribbing to more involute and discoidal ones with a finer and more sigmoidal costation; there is also the same increase of the elaborateness of the suture lines in each of these cycles. Similar thoughts have been expressed, in a more general sense, or with regard to other groups, in recent papers of Schindewolf (1940) and of Zoch (1940).

VERNAY COLLECTION OF CRETACEOUS (ALBIAN) AMMONITES FROM ANGOLA. INTRODUCTION AND PART I: THE SCULPTURED, NORMALLY COILED AMMONITES

BY OTTO HAAS

Although the Albian ammonite fauna from the environs of Lobito, Angola, has, since 1888 (Choffat) repeatedly been studied, chiefly by Spath (1922), the richness of the present collection seems to justify a detailed restudy, all the more so since it includes many representatives of genera hitherto unknown or but little known from Angola, and since it permits careful investigation of the ontogenetic development of most of the forms described. Parts II and III of this paper will deal with the smooth, or almost smooth, normally coiled ammonites and with the abnormally coiled ones, respectively, whereas Part I, now in press, includes the sculptured, normally coiled forms, referred to the following seven genera: *Dipoloceras* (5 forms, 2 of them new), *Hysteroceras* (22 forms, 16 new), *Neokentroceras* (14 forms, 9 new), *Pervinquieria* (24 forms, 19 new), *Elobiceras* (18 forms, 11 new), *Prohysteroceras* (6 forms, 2 new), and *Neoharpoceras* (2 forms, both new). The most interesting forms and the intergeneric resemblances are discussed, and the phylogenetic inferences which might be drawn from the latter are summarized.

SKOLITHOS, DIPLOCRATERION, AND *SABELLIDITES* FROM THE CAMBRIAN ANTIETAM FORMATION OF MARYLAND

BY B. F. HOWELL

Skolithos linearis is common in the Antietam sandstone at a number of localities in Washington County, Maryland. A larger, new species of *Skolithos* is found with it at one locality, and *Diplocraterion parallelum* Torell, previously known only from the Lower Cambrian of Sweden, is associated with it at another. At a third locality a new species of *Sabellidites,* a genus hitherto reported only from the Lower Cambrian of Russia, occurs with *S. linearis.* The new species of *Skolithos* and *Sabellidites* will be described in the Bulletin of the Wagner Free Institute of Science.

SKOLITHOS WOODI IN THE UPPER CAMBRIAN OF MINNESOTA

BY B. F. HOWELL

Skolithos woodi Whitfield, originally described from the "Potsdam" formation of Wisconsin, has been found in the Upper Cambrian Franconia and Jordan formations of Minnesota. Burrows of this species are shorter and smaller in diameter than those of the Lower Cambrian *Skolithos linearis* Haldeman and the Lower Ordovician *Skolithos minnesotensis* James, and *S. woodi* is believed to be a valid species. The writer is indebted to Professor Clinton R. Stauffer for the opportunity to examine Minnesota examples of *S. woodi* and to compare them with topotypes of *S. minnesotensis.*

MIDDLE ORDOVICIAN FORMATIONS IN CENTRAL PENNSYLVANIA

BY G. MARSHALL KAY

Mohawkian and older sediments west of the Adirondack axis in Pennsylvania are classified as:

Mohawkian series—Trenton group: basal Reedsville black shale (upper Utica); Coburn limestone, 175 feet at Salona (Whitcomb) (Cobourg); Salona limestone, 339 feet at Salona (Whitcomb) (Denmark and Shoreham); Nealmont limestone, 65-135* feet, including type Rodman, Lemont and Center Hall (Hull and Rockland). Black River group: Valentine limestone, 145-0 feet (Lowville); Benner limestone (new) (Pamelia), comprising Stover member, 93*-0 feet, dark, heavy-ledged limestone, and Snyder member, 96*-0 feet, sublithographic light, oölitic and pebbly limestone.

Chazyan (?) series—"Carlim group": Hatter limestone, 57-96* feet, dark and siliceous limestone; Loysburg formation: Clover member, 46*-60 feet, laminated, rather pure limestone; and pre-Clover laminated magnesian and pure limestone, at least 400 feet.

The Adirondack axis passes through upper Path Valley. Salona limestone of normal thickness and character in Blacklog Valley converges to less than half, and becomes principally shale above the basal member; Nealmont limestone converges and overlaps from a maximum in the Kishacoquillas-upper Penn Valley belt to about 60 feet. The Black River group thins eastward across the axis, the last appearing member, the Snyder, being about 10 feet at St. Thomas; succeeding members enter westward, the limit of the Stover approximating Jacks Mountain, of the Valentine, a line from Tyrone to south of Pleasant Gap and Millheim. The Carlim has characteristic lithology to the axis, the Clover-Snyder interval increasing to the east.

* Thickness of new unit at type section, all at Union Furnace.

ORDOVICIAN HELIOLITIDAE FROM MANITOBA

BY E. LEITH

Heliolitid corals though comparatively rare in the Ordovician rocks of Manitoba are an important element in the coral fauna of the province. In the Selkirk member of the Red River formation *Protrochiscolithus kiaeri* Troedsson is represented by unusually large, hemispherical coralla with diameters up to 8 inches and incrustations around large cephalopods; the lamellae attain a thickness of over 1½ inches. Troedsson recorded this species from the Cape Calhoun beds of northern Greenland. *Protarea richmondensis* Foerste is very rare in the Stony Mountain formation and occurs as small hemispherical coralla. A very remarkable specimen of an arborescent corallum has also been collected in the Stony Mountain formation. Four thick branches arise from a "stump" with a diameter of 1½ inches, and the corallum

attains a height of 10 inches and a width of 7½ inches. Unfortunately the internal structure is poorly preserved. This arborescent specimen probably represents a new genus.

PROBABLE LAUREL-BROWNSPORT OVERLAP IN THE GREAT LAKES STATES

BY HEINZ A. LOWENSTAM

Study of the Lower Waukesha fauna in the Niagaran of the Chicago area led to the suspicion that there is a northward Laurel overlap. A re-examination of the Laurel fauna at St. Paul, Indiana, revealed the existence of hitherto undescribed faunal elements of diagnostic stratigraphic significance. The presence of these same elements in the Lower Waukesha tends to confirm this idea of Laurel overlap. Hitherto unrecorded faunal elements from the Monticello stage (Lower Hopkinton) of northeastern Iowa also support the existing belief of a close relationship to the Laurel fauna.

Species characteristic of the Brownsport and Bainbridge fauna were found in the rubble from the Chicago drainage canal near Blue Island. The stratigraphic position of this fauna, judging from the closest Niagaran exposures, can be regarded as either Upper Waukesha or basal Racine. The finding of a Brownsport fauna in the Upper Liston Creek formation (reef) at Wabash, Indiana, and the presence of hitherto unrecorded Brownsport faunal elements in the Louisville limestone near Louisville, Kentucky, indicate a northward migration route along the western flank of the Cincinnati anticline. The Bainbridge elements in the Blue Island fauna demonstrate the presence of an open migration route through the Mississippi valley area.

The faunal evidence presented indicates an invasion of the so-called southern Laurel and the recurrent Brownsport faunas into the realm of the so-called "northern" faunas.

CORRELATION OF METASEDIMENTS IN SOUTHEASTERN NEW YORK

BY RALPH LEROY MILLER

Equivalence of Lowerre quartzite, Inwood limestone, and Manhattan schist of southeastern New York with Poughquag quartzite, Wappinger limestone, and Hudson River shale of the Hudson Valley has been suggested. Opposing views on this problem are tenable because distinctive and persistent stratigraphic units within the formations have not been found and because uncertainty exists whether one or more major thrust faults intervene between the two sequences.

Restudy of the Poughquag quartzite in the type region on the northwest flank of the Hudson Highlands has led to the following conclusions:

(1) The Poughquag quartzite does not exceed 250 feet in thickness and averages around 200 feet. Published estimates of 600 feet for the Poughquag have been cited as evidence opposing correlation with the much thinner Lowerre.
(2) The Poughquag formed a continuous deposit over this region, so that its absence at the bedrock surface where normally expectable must be explained on structural grounds.
(3) Numerous outcrops of Poughquag in the normal stratigraphic position on the northwest flank of the Highlands seem to preclude major thrusting along this border, although minor thrusting has occurred locally, especially near the Hudson River.

REVISED CLASSIFICATION OF PALEOZOIC CRINOIDEA

BY RAYMOND C. MOORE AND LOWELL R. LAUDON

Preparation of a chapter on fossil crinoids for a new edition of *North American Index Fossils* by Grabau, Shimer, and Shrock has led to proposed revision of classi-

fication that includes introduction of some new orders and suborders, several new families, and emendation of the grouping in a number of long-recognized families. The new classification is based on the very extensive morphologic studies of many previous workers, including especially Bather, Carpenter, Goldring, Hall, Kirk, Meek, W. E. Schmidt, Springer, Wachsmuth, Wanner, and Worthen, and takes account of interpreted relationships as given comprehensively by Bassler, Bather, Jaekel, Moore and Plummer, Müller, Springer, Wachsmuth and Springer, Wanner, Zittel, and others. The writers' researches, dealing mainly with Devonian, Carboniferous, and Permian crinoids, have been supplemented by studies of Ordovician, Silurian, and later Paleozoic crinoids, as well as some post-Paleozoic crinoids, in numerous museums of North America and Europe.

The Crinoidea are deemed to be a polyphyletic assemblage of echinoderms, some of the orders being only very distantly related and having had their origin considerably before the time represented by the oldest known fossils assigned to them. Structural characters of the crinoids that seem to have most significance in evolution and in development of a phylogenetic classification of the class include (1) plan of the dorsal cup below the radials, involving differentiation of monocyclic and dicyclic forms, (2) nature of sutural union of plates belonging to the calyx, (3) tegminal or subtegminal position of the mouth and proximal portions of the ambulacra, (4) structure of the arms and especially nature of the articulation at the base of the free arms, (5) characters of the posterior interradius and tegmen that are correlated with the gut and anus, and (6) form of the dorsal cup. The importance of these morphologic features and others varies much in different groups of crinoids, and it seems clear that a natural classification must be founded on certain combinations of characters. Stratigraphic position of the multitudinous kinds of known crinoids must be held in view, and it is necessary to discriminate homeomorphy from similarities that are genetically highly significant. The new classification of Paleozoic Crinoidea is believed to incorporate the considerably expanded knowledge of these fossils that has been obtained from investigations by several workers in recent years.

NORTH AMERICAN PLEOSPONGIA

BY VLADIMIR J. OKULITCH

Pleospongia (Archaeocyathi) are an independent and short-lived class of Porifera. Stratigraphic range, limited to Lower and Middle Cambrian, is remarkable in the light of worldwide distribution in Australia, North America, Europe, Africa, and Asia. Some 400 species are known with about 40 on this continent.

The most typical are goblet-shaped with distinct inner and outer walls, connected by parieties, tabulae, or irregular vesicular tissue. Numerous pores give the skeleton an appearance of exceedingly fine mesh.

Geographic and stratigraphic distribution of Pleospongia, ecology, and faunal associations are considered. Morphology, ontogeny, and phylogeny are described in detail.

Five subclasses (Monocyatha, Archaeocyatha, Anthocyatha, Exocyatha, and Uranocyatha) show fundamental differences; their relationship is indicated by early stages and methods of skeletal construction. Monocyatha have single walls, laminar, perforated by regular pores, or more or less spongy. Archaeocyatha contain all types invariably having double-walled skeleton, cup-, beaker-, or saucer-shaped. The spitzes strongly resemble the Monocyatha, which suggests derivation from *Monocyathus*-like ancestors. Four orders are Acanthinocyathina Okulitch, Syringocnemina Okulitch, Ajacicyathina Bedford, and Metacyathina Bedford. Anthocyatha superficially

resemble the Anthozoa. Uranocyatha include hollow spherical, oval, or gastrulalike shapes. Exocyatha are independent or encrusting Pleospongia consisting of irregular vesicular or cellular tissue without definite walls.

In Labrador, Quebec, New York, Virginia, Georgia, California, Nevada, Washington, and British Columbia Pleospongia are confined to the Lower Cambrian. A single species occurs in the Middle Cambrian of New Brunswick. Practically all built extensive reefs.

All known American species are fully described. Since 1935 the number of known American forms has increased from 13 to 40. Their importance as index fossils has greatly increased. Pleospongia, hitherto neglected and very imperfectly known, represent one of the most important groups of Cambrian organisms. (Geological Society project.)

ZONING OF THE CONTINENTAL SHELF FORAMINIFERA FROM THE GULF OF MAINE TO CAPE HATTERAS

BY FRANCES L. PARKER

An ecologic study has been made of the continental shelf Foraminifera from material collected by H. C. Stetson between the Gulf of Maine and Cape Hatteras. The distribution of the more common benthonic and pelagic forms has been worked out on a percentage basis. The region between Cape Cod and Cape Hatteras can be divided into four faunal zones, running parallel to the shore, which contain distinctive groups of benthonic Foraminifera. That east and north of Cape Cod cannot be so divided. The physical characteristics of the open-sea waters of the area were analyzed in an attempt to find the reasons for the zoning beyond the depth of 15 meters. It is probable, in view of present knowledge of living forms and of the physical conditions of their environment, that temperature is the chief controlling factor. Whether this influence is direct, or indirect through the food supply, or both, cannot be said.

The pelagic fauna was studied, and its numerical ratio to the benthonic fauna computed. It consists of 13 species composing 80 per cent of the total fauna at the break in slope, but decreasing rapidly in numbers toward shore until, at a depth of 50 meters, it has almost entirely disappeared. It is suggested that this decrease inland from the break in slope is due to both salinity and temperature changes which occur at this point and perhaps also, mechanically, to the longshore current set up by these physical changes.

LOWER CRETACEOUS MICRO-CRINOIDS FROM TEXAS

BY RAYMOND E. PECK

Small, stemless, highly ornamented crinoid calyces and dissociated brachials are abundant in the Lower Cretaceous of Texas. *Roveacrinus* Douglas, recorded from the Cretaceous of England and Germany, is represented by a few specimens. All other calyces belong to new genera.

Many of the calyces represent a group that paralleled the development of the comatulids in that the stem was lost at an early stage and a plate resembling the comatulid centrodorsal developed. But this "centrodorsal" lacks cirri and is highly ornamented by ridges, flanges, and spines.

On most of the species it is possible to trace stages of growth from the small calyx with an easily recognized stem facet to the mature calyx with a well-developed "centrodorsal" plate.

APPLICATION OF RELATIVE GROWTH METHOD TO TRILOBITES

BY FRED B PHLEGER, JR.

Preliminary relative growth analyses have been made of several measurements of trilobite cephala, pygidia, and complete specimens in the collections of the Museum of Comparative Zoology. The purpose has been to determine if this method of analysis could be applied to trilobites and whether it could be used in attacking problems of relationship, as in the case of fossil vertebrate skulls.

In five species, representing four families, the relative growth formula ($y = bx^{\alpha}$, where y and x are measurements and b and α are constants) expresses an approximately correct relationship between specimens of different sizes. Degree of correlation was very good where good specimens were available. The α values in most cases examined fluctuate around unity, suggesting harmonious genetic organization. Differences between two species of *Dalmanites* are indicated by differences in the values for b. In *Isotelus gigas* the relative growth analysis suggests that the anterior segment of the median lobe of the pygidium had an accelerated growth rate, out of harmony with the rest of the pygidium. In the same species the cephalon, thorax, and pygidium had relative size increases in growth which were equal.

Limitations of this method as applied to trilobites are lack of sufficient perfect specimens and also the relatively few important measurements which can be made.

FORAMINIFERAL DEPTH ZONES FROM THE CONTINENTAL SLOPE

BY FRED B PHLEGER, JR.

The percentage frequencies of benthonic Foraminifera occurring in 67 bottom samples from the continental slope have been analyzed according to depth. The samples are from the latitude of Georges Bank to the latitude of Cape May, and an entire depth traverse of the continental slope is represented. Three zones have been recognized as follows: The upper slope zone, from 200 meters to 600-1000 meters, is characterized by the presence or relative abundance of *Robulus, Cassidulinoides bradyi, Bolivina subeanariensis,* and *Bulimina marginata.* The middle slope zone, from 600-1000 meters to 1600 meters, is characterized by the relative abundance of *Bulimina aculeata, Bulimina exilis,* and *Angulogerina* sp. 1. The lower slope zone, below 1600 meters, is particularly marked by the relative abundance of *Uvigerina peregrina; Bulimina inflata* also may be useful in recognition of this zone. The depth zone, 600 to 1000 meters, has overlap ranges of species characteristic of the upper and middle slope zones.

Temperature variation may be the primary controlling factor causing this zonal distribution, either directly or indirectly. The major faunal discontinuity occurs at 600 to 1000 meters, and the isotherms of 4 to 6 C more or less coincide with this depth range on the continental slope.

MIDDLE ORDOVICIAN LIMESTONES OF THE MEDIAN AND NORTHWEST BELTS OF VIRGINIA AND TENNESSEE

BY CHILTON E. PROUTY

The limestones between the top of the Beekmantown and the base of the Trenton have been divided into 28 lithologic and faunal zones comprising six formations (Cooper and Prouty, 1940). These have been traced in Virginia and Tennessee. Type Lenoir of Tennessee, nodular limestone containing *Maclurites* and *Girvanella,*

passes well below the *Helicotoma-Lophospira* zone (Murfreesboro) in Virginia and changes to dark cherty and coarse gray limestones; this coarse limestone has been called Holston in the median belts of Virginia but is older than similar beds called Holston in most of the Tennessee belts. Above the Virginia "Holston," a *Nidulites* zone, directly beneath the *Helicotoma-Lophospira* zone, extends throughout the median belts of Virginia. Southwest of Newcastle, Virginia, this zone carries *Echinosphaerites* and *Receptaculites* and has been mapped as Stones River; it is called Athens in the same belt from south of Goodwins Ferry to northeast of Abingdon. Above the *Helicotoma-Lophospira* zone, a nodular limestone carrying *Maclurites* and *Girvanella* extends from Narrows, Virginia, to at least Thorn Hill, Tennessee; it has been classed as Lenoir in many sections. The limestones of the median belts of both Virginia and Tennessee show the most nearly complete sections, whereas the northwest belts show large breaks in the lithologic and faunal record. A study has been made of the distribution and relations of these units to newly defined formations.

FAUNAL CONTENT OF MARYVILLE FORMATION

BY CHARLES E. RESSER

Fossils have not been found in the Maryville formation where it is typically developed as a limestone, in southwestern Virginia and Tennessee, but in the Forked Deer section on Clinch Mountain intercalated shale layers contain the *Perioura* fauna. Recently the Maryville was traced from that section southward, and the shale content increases until in southern Tennessee and Alabama so little limestone remains that the formation is included in the Conasauga shale.

By this means two additional faunal zones were located in limestone layers in unquestioned Maryville. About a third of its thickness above the base *Alokistocare georgense* was found, and near the middle the *Eteraspis* (*Blainia glabra*) fauna; neither, however, is a determined relationship to *Perioura*. From this information it is possible to assign faunas in Georgia and Alabama to the Maryville. They include the large *Olenoides* fauna from Center, Alabama.

NEW MOLLUSKS FROM THE TRENT FORMATION (MIOCENE) OF NORTH CAROLINA

BY HORACE G. RICHARDS

As part of a co-operative program between the Academy of Natural Sciences of Philadelphia and the North Carolina State Museum, some field work has been undertaken in eastern North Carolina. One of the most significant results of the program to date has been the discovery of a large invertebrate fauna near Silverdale, Onslow County, North Carolina, from a marl pit in the Trent formation of lower Miocene age. This is near the locality where Kellum described a fauna of 21 species of which 16 were known only from the Trent. Earlier workers had regarded the Trent as of Eocene age, but the fauna described by Kellum suggested a basal Miocene age, closely related to the Tampa limestone of Florida. The present study has added at least 20 species to the Trent fauna of which about 10 are new. The additions to the fauna strengthen the belief that the Trent formation is of lower Miocene age. The most interesting species in the list is a new *Donax*, very closely related to the recent *D. punctostriatus* Hanley of the west coast of Mexico. This occurrence is further evidence for a Tertiary sea connection across Mexico.

MIOCENE INVERTEBRATE FAUNA OF NEW JERSEY

BY HORACE G. RICHARDS AND ANNE HARBISON

The present paper is part of a co-operative arrangement between the Academy of Natural Sciences of Philadelphia and the New Jersey Geological Survey and State Museum. The fauna of the Kirkwood formation of New Jersey, of Miocene age, has been studied and analyzed. Three species of corals, one bryozoon, one brachiopod, one echinoderm, three barnacles, and 152 mollusks—a total of 160 species—are recorded. Of these 4 are new, and 35 additional are known only from the Kirkwood. A study of this fauna, both from surface outcrops as well as from numerous wells, shows that the Kirkwood formation is composed of several phases. It is correlated with the Chesapeake group of Maryland and contains elements of both the Calvert and St. Mary's formations.

MUSCLE SCAR PATTERNS IN SOME PENNSYLVANIAN OSTRACODES

BY HAROLD W. SCOTT AND GLENN FORD

Numerous muscle scars were found preserved on the casts of Pennsylvanian ostracodes collected from western Kentucky. The ostracodes come from a marine shale that overlies coal No. 9 (upper Carbondale group) in eastern Muhlenburg County.

Muscle scars are seldom found in Paleozoic ostracodes but are common in Mesozoic and Cenozoic specimens. They are of great aid in orientation because they usually occur slightly anterior of a median point. They are also of considerable aid in classification of the ostracodes. The pattern between families is distinct, usually reliable between genera, and sometimes diagnostic between species.

The Pennsylvanian genera on which the scars are preserved are *Healdia, Bythocrypris, Harltonella, Youngiella, Cavellina, Sulcella,* and *Cytherella.* The patterns in the Paleozoic genera tend to be more complex than those found in most modern forms.

WALL STRUCTURE OF FAVOSITIDAE

BY DAVID H. SWANN

The intercorallite walls of several species of *Favosites* and related genera are integrate. Examination of thin sections of walls of this type reveals five structures separating neighboring corallites: a central zone of yellowish translucent homogeneous calcite, two thin opaque lines adjacent to the central zone, and two fibrous, buff-colored border zones. The central zone is composed of cryptocrystalline calcite; the *c* axes of the minute crystals are vertical implying deposition from a horizontal coenosarc; the zone may be called an intramural coenenchyma. The thin dark bands are primary walls, homologous to the "epitheca" of tetracorals. The fibrous border zone is a felted mass of subparallel calcite microcrystals whose statistical *c* axis is normal or nearly normal to the wall plane; this is the peripheral stereozone of Hill's tetracoral nomenclature.

In other wall types occurring in Favositidae, this basic plan is modified by excessive thickness, attenuation, or by the complete disappearance of certain zones.

CHAZYAN AND RELATED BRACHIOPODS

BY E. O. ULRICH AND G. A. COOPER

This embodies the results of a study of post-Canadian—pre-Trenton brachiopods of the United States and parts of Canada. The collection includes specimens from the Lake Champlain area of New York, the Appalachians from New York to Alabama, the Mississippi Valley, the Arbuckle Mountains and Criner Hills of Oklahoma, and parts of the Great Basin. Altogether 91 genera are distinguished, 18 of them new. The largest group is the Orthacea with 27 genera; the inarticulates are next with 17 genera, the strophomenids and plectambonitids follow with 12 each, the rhynchonellids, camerellids, and spiriferids are represented by 5 each, the clitambonitids and syntrophids by 3 each, and the triplesids by 2 genera.

Most of the material consists of silicified specimens that have been dissolved out of limestone and thus are superb for morphological studies. An unusually large number of plectambonitids appears and permits considerable expansion of that group. Initiation of four punctate stocks takes place in the time span represented by the study. Five genera of spire bearers appear. Thus two important new brachiopod developments are inaugurated during this time. Many Baltic elements have been identified in the faunas of Virginia and Tennessee.

As this monograph considers about 50 species, it will be a great aid to refinement of stratigraphy particularly in the southern Appalachians from which no important paleontological studies have ever been undertaken. Furthermore, lines of brachiopod evolution become clearer between the Lower Ordovician and the Trenton where a great gap in knowledge had hitherto existed.

OZARKIAN AND CANADIAN CEPHALOPODS—PART II: BREVICONES

BY E. O. ULRICH, AUG. F. FOERSTE, AND A. K. MILLER

More than half of the known specimens of Ozarkian and Canadian cephalopods are brevicones. They are of widespread occurrence and are locally abundant in the United States, Canada, and Newfoundland. In age they range from Lower Ozarkian to uppermost Canadian, but the bulk of those now at hand came from the Middle and Upper Ozarkian and the Upper Canadian. Comparatively little knowledge is available in regard to related faunas outside of North America, but such occur in both western Europe and eastern Asia.

Most of the known forms are superficially similar. They differ chiefly in the shape of the conch and the nature of the siphuncle. Primarily on the basis of these features, they have been divided into four families: the Piloceratidae (37 species representing 6 genera), the Cyclostomiceratidae (9 species, 3 genera), the Cyrtendoceratidae (141 species, 13 genera), and the Beekmanoceratidae (1 species, 1 genus). It is perhaps significant that the great majority of our specimens fall readily into one of two groups, the Cyrtendoceratidae, characteristic of the Middle and Upper Ozarkian, and the Piloceratidae, essentially limited to the Upper Canadian.

CAMBRO-ORDOVICIAN TRILOBITES OF THE ADIRONDACK BORDER

BY ROBERT R. WHEELER*

The Cambrian-Ordovician boundary in the Adirondack-Border region is redesignated on the basis of new physical and faunal evidence (the extinction of the Saukiinae and the appearance of the Asaphidae).

* Introduced by P. E. Raymond.

An interesting example of faunal facies is illustrated by the mingling of presumably diagnostic trilobites in the Upper Cambrian of northern New York and Vermont. *Elvinia* and *Ptychaspis* of early Franconia age characterize the Theresa formation, while *Idahoia* of the upper Franconia and the upper Trempealeau genera *Plethopeltis* and *Plethometopus* occur together with late Cambrian Saukiinae (*Neosaukia, Stenosaukia,* and *Richardsonella*) in the Hoyt formation. Moreover, *Ptychaspis* and *Plethopeltis* are found together in littoral deposits marking the limits of maximum transgression on the western margin of the Adirondacks.

The Lower Beekmantown—Tribes Hill—formation contains *Symphysurina* and *Bellefontia* in the lowest member and *Hystricurus* in the middle and upper members. The position of *Lloydia* is uncertain for it has not been found in the foreland sequence; however, it occurs with Tribes Hill fossils in the Central and Phillipsburg sequences of northwestern Vermont and Quebec.

The Upper Beekmantown—Cassin formation—revealed several asaphids, notably *Isoteloides* in the lower beds and *Asaphellus?* occurring with *Bolbocephalus* in the middle beds. Although the Lower Ordovician Asaphidae need revision, their abundance, rapid phylogeny, and wide distribution suggest their future utility in correlation and permit a tentative differentiation of zone markers.

SILURIAN FOSSILS FROM RIPOGENUS DAM, MAINE

BY BRADFORD WILLARD

At the request of Dr. Lloyd W. Fisher of Bates College, the author identified a collection of Silurian fossils made by Dr. Fisher and Mr. Alan Sawyer. The material came from Ripogenus Dam in north-central Maine at the southern end of Chesuncook Lake. The fossils occur in limestone of the Ripogenus series. The 1933 geologic map of Maine records limestone in the upper part of the Silurian system in the State. Rocks of this system border the southern part of Chesuncook Lake. Dr. Fisher has authorized the writer to issue the following statements. The material is well preserved, though somewhat distorted. Identification was not particularly difficult. The fauna is dominated by corals, brachiopods, and trilobites. It bears a remarkable similarity to the Silurian of western New York and Ontario and is assigned to the Lockport of Guelph of late middle Silurian age. The faunal list follows:

	Range
Zaphrentis turbinata (Hall)	Lockport
Enterolasma cf. *caliculum* (Hall)	Rochester, Lockport
Diplophyllum sp. nov.?	
Favosites niagarensis Hall	Niagaran
F. sp. undet.	
Halysites catenularia (Linnaeus)	Silurian
Heliolites elegans Hall	Lockport
Corals, undet.	
Berenicea ?	
Pentamerus oblongus Sowerby	Niagaran
Conchidium ?	
Whitfieldella nitida (Hall)	Niagaran
Atrypa reticularis (Linnaeus)	
Homeospira ?	
Ilionia ?	
Poleomita crenulata (Whiteaves)	Niagaran, Guelph
Euomphalopteris valeria (Billings)	Guelph
Calymene niagarensis Hall var. nov.	
Bumastus ioxus (Hall)	Niagaran
Dalmanites limulurus (Green)	Clinton, Lockport

LATE PALEOZOIC FAUNAS OF ALASKA*

BY JAMES STEELE WILLIAMS

Faunas of lower Carboniferous and Permian ages have been collected, mostly by geologists of the Alaskan Branch of the Geological Survey, from many localities in Alaska. Additional collections made by the writer and associates in 1940 from most of the principal late Paleozoic areas have provided material needed for the completion of studies of these faunas begun years ago by G. H. Girty.

No marine faunas definitely of Pennsylvanian age are known from Alaska, although some deposits largely of terrigenous origin may be Pennsylvanian. A marine fauna from southeastern Alaska that has been referred to the Pennsylvanian was found to be more probably Mississippian than Pennsylvanian, although there is difficulty here as elsewhere in determining the Mississippian-Pennsylvanian boundary.

The Permian faunas are closely related to the faunas of the Phosphoria and other formations in the western United States. Recent studies show that some of them are also related to but were not necessarily synchronous with faunas of the Brachiopodenkalk of Ellesmere and Heibergs Land, Brachiopodenkalk of Eastern Greenland, Spiriferenkalk of Spitzbergen, and other Arctic faunas and also possibly to some faunas in the U. S. S. R. that have been referred to the so-called "Schwagerina" zone. Precise correlations and age assignments are premature because (1) The Alaskan faunal studies have not been completed, (2) some of the older faunas may possibly belong in the zone whose Carboniferous or Permian age is in dispute, and (3) the age, correlation, and possible facies (as against time) implications of faunas needed for comparison are not well known.

PENNSYLVANIAN BRACHIOPODA FROM NEW MEXICO

BY JOHN A. YOUNG, JR.

This is the second of a series of articles on the paleontology of the Magdalena group of the Sangre de Cristo Mountains of north-central New Mexico. The brachiopod fauna as found in the region near Taos and the Moreno Valley is given. Two new genera are erected, and 10 new species described. The intrarelationships of the *Spirifer rockymontanus—S. opimus—S. occidentalis* group are considered. A recently discovered paratype of *S. rockymontanus* is illustrated.

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* Published with permission of the Director, Geological Survey, U. S. Department of the Interior.

PACIFIC COAST BRANCH MEETING AT STANFORD UNIVERSITY IN APRIL

STRATIGRAPHIC SETTING OF THE FOSSIL LAKE FAUNA

BY IRA S. ALLISON *

Mammalian fossils from the Fossil Lake locality of northern Lake County, Oregon, found mainly on the surface as deflation residuals, occur in place near the top of the main body of Pleistocene lake sediments and are associated with a minor unconformity, flat-pebble conglomerates, disturbed bedding, and other shallow-water features. The animals evidently had access to the area after the lake level had declined more than 200 feet. Beds above the principal mammal horizon yield numerous bones of birds and fish.

MAMMALIAN AND AVIAN ICHNITES IN DEATH VALLEY

BY H. DONALD CURRY †

Fossil tracks of mammals and birds, unlike those of lower animals, are seldom recorded. In Death Valley, California, ichnites of this type are relatively common and occur at several localities in rocks of late Tertiary and Pleistocene age. The Copper Canyon region in particular has yielded hundreds of well-preserved tracks, found at a number of horizons in a 3000-foot section of folded playa beds. Included in the collection are at least eight kinds of carnivores, three horses, a proboscidean, three or more camelids, a number of other artiodactyls, several web-footed, and numerous large and small wading birds. Marked differences in foot structure, stride, and body are noted from the ichnites, even in obviously related forms, and serve to distinguish various types. In the absence of skeletal material and lack of similar ichnite occurrences for comparison, specific determinations cannot yet be made. However, preliminary study of the size of the horses as well as other diagnostic features of the fauna suggests that the age of the Copper Canyon beds is middle Pliocene.

Further tentative conclusions are reached concerning the life habits of the animals, climate, and ecology based on these tracks and on the lithology of the rocks in which they occur.

QUATERNARY AVIFAUNA FROM McKITTRICK ASPHALT, CALIFORNIA

BY IDA DE MAY †

Studies of the fossil birds in the McKittrick collection of the California Institute of Technology indicate that this assemblage differs from other McKittrick collections in age and in type of environment represented. It is evident that this McKittrick avifauna is somewhat younger than those described by Loye Miller, not only because the percentage of extinct species has decreased but also because the percentage of large vultures and eagles is not so great as in the typical Pleistocene of Rancho La Brea and in previous McKittrick collections. Smaller numbers of aquatic birds and great abundance of small hawks and owls probably reflect environmental changes in the vicinity of the tar seeps. From this collection comes the first record of the California condor from the McKittrick asphalt, and the first fossil or subfossil occurrence of a nighthawk and poorwill. The extinct California turkey (*Parapavo*) is still absent at the locality.

* Introduced by John C. Merriam.
† Introduced by Chester Stock.

MEGAFAUNAL ZONES OF THE OLIGOCENE OF NORTHWESTERN WASHINGTON

BY J. WYATT DURHAM

Studies upon strata commonly referred to the Oligocene in the Quimper Peninsula, type Blakeley, and type Twin Rivers sections, where fossils are fairly abundant, indicate the presence of six megafaunal zones in strata ranging in age from that of the Gries Ranch beds to the upper Twin Rivers formation. In the lower zone characteristic fossils are *Molopophorus stephensoni* Dickerson, *Bruclarkia* n. sp., *Perse* n. sp. A, and *Spisula packardi* Dickerson. Fossils from the second zone are *Molopophorus gabbi* Dall, *Perse* n. sp. B, *Pitar clarki* (Dickerson), and *Spisula pittsburgensis* Clark. The third zone includes strata with *Turritella* n. sp., *Molopophorus lincolnensis* n. subsp., and *Bruclarkia columbianum* (Anderson and Martin). Characteristic fossils of the fourth zone are *Turritella porterensis* Weaver, *Perse lincolnensis* (Van Winkle), *Molopophorus lincolnensis* Weaver, *Pitar dalli* (Weaver), and *Venericardia hannibali* Clark. *Acila shumardi* (Dall) ranges through the four lower zones. Important fossils from the fifth zone are *Turritella blakeleyensis* Weaver, *Euspinacassis rex* (Tegland), *Miopleiona weaveri* Tegland, *Pitar arnoldi* (Weaver), and *Turcicula washingtoniana* Dall. The sixth zone has as characteristic fossils *Euspinacassis apta* (Tegland), *Turritella diversilineata* Merriam, *Turcicula turbonata* Clark, *Macrocallista weaveri* Clark, and *Pitar arnoldi ethringtoni* (Tegland). *Acila gettysburgensis* (Reagan) ranges throughout the last two zones. Zone six is overlain by strata containing *Anadara osmonti* (Dall). Zone one rests disconformably on strata correlated with the Keasey formation and which in turn unconformably overlie beds containing *Turritella olequahensis* Weaver and Palmer. The strata in which these six zones are found have been included within the Refugian and Zemorrian stages by Kleinpell.

PRELIMINARY RESULTS OF SURVEY OF BATHYMETRIC DISTRIBUTION OF MARINE GASTROPODA

BY J. WYATT DURHAM

The survey was made to determine whether or not the living gastropod genera are restricted in their bathymetric distribution. Data pertaining to each species were obtained from works on recent Mollusca and were assembled on cards, including the locality, depth, temperature, type of bottom, number of specimens, and mode of occurrence. Where depth has not been reported the occurrence has not been used; unfortunately this eliminates a majority of the reports. Assistance in the compilation of the data was furnished by the personnel of the Work Projects Administration, Official Project No. 65-1-08-62, Unit A-1. Approximately 9000 records have been assembled to date. For preliminary analysis the localities have been referred to three climatic zones on the basis of surface temperature. Cards for a given genus were then assembled as to zone, and the maximum, minimum, and median depth ranges were determined.

Significant results are: some genera are stenobathic, as *Thais* (climatic range 5 to 20 degrees C., 59 records), depth 0 to 129 meters, median 19 meters; other genera are eurybathic, as *Fusus* (climatic range above 20 degrees C., 66 records), depth 0 to 1849 meters, median 155 meters; third, the most closely restricted taxonomic units have the most restricted range, as *Bursa* (*s. l.*) (28 records), depth 0 to 289 meters, median 27 meters, while *Bursa* (*Colubrinella*) (14 records) ranges from 0 to 27 meters with a median of approximately 0 meters.

It is hoped that future reports on recent Mollusca will include depth, temperature, type of bottom, number, and condition of specimens in their data. Information as to sources of additional data will be greatly appreciated.

PRELIMINARY REPORT ON BIRDS FROM SAN JOSECITO CAVE, NUEVO LEON, MEXICO

BY LOYE MILLER*

A Pleistocene accumulation in a limestone cavern is being excavated by the California Institute of Technology on the eastern flank of Sierra Madre Oriental. Over 30 species of birds have been identified including three that are new to science. Other extinct species were earlier described from the California Pleistocene giving the fauna a stronger resemblance to Rancho La Brea than to subfossil cave faunas from Texas and New Mexico. Several predatory species evidently nested in the cavern mouth, and other species were doubtless brought in as prey. Great numbers of young birds of various stages give us an interesting embryologic series of certain bones. *Teratornis, Wetmoregyps, Neophrontops, Neogyps,* California Condor, a large Mackaw, and a short-legged turkey are among the interesting items of the avifauna.

FOSSIL BIRDS OF CALIFORNIA WITH ANNOTATIONS AND BIBLIOGRAPHY

BY LOYE MILLER AND IDA DE MAY*

Thirty localities in California have produced bird remains of Tertiary or Pleistocene age as follows:

Miocene—6 localities—14 species
Pliocene—8 localities—11 species
Pleistocene—16 localities—166 species

These deposits represent areas in the Sierran foothills, the great interior valley, the Mojave Desert, the Coastal plain of Southern California and the shore line of San Francisco, San Luis Obispo, Santa Barbara, Los Angeles, and San Diego counties.

The accumulations represent coastal gravels, estuaries, lacustrines, fluviatiles, tuffs, cavern and asphalt deposits. More than 100,000 specimens have been collected and examined. Twelve investigators have devoted especial attention to birds, and a large bibliography has developed especially within the last 30 years.

ADDITIONS TO THE VERTEBRATE FAUNA OF ASTORIA FORMATION OF OREGON

BY E. L. PACKARD

The lower beds of the Astoria formation contain marine mammals wherever they occur between Waldport, Lincoln County, and Astoria in Oregon, and even in Washington. Heretofore, only mammals have been reported, the list being *Desmostylus hesperus* Marsh, *Desmatophoca oregonensis* Condon, and *Cephocetus oregonensis* Packard and Kellogg. Since the last form was described, much cetothere material has been accumulated at Oregon State College.

This list of mammals may be increased by a small porpoise, known from parts of five skulls collected over a period of years, but none of which is probably describable. Sharks' teeth occur, but systematic collections are lacking. Many isolated fish

* Introduced by Chester Stock.

vertebrae having diameters of at least 10 centimeters are recorded. Classification awaits additional material and investigation.

The skull of a gigantic chelonian discovered about 2 years ago is in the Oregon State College Museum. Recently a carapace fragment was obtained. The skull is well preserved, and most of the bones can be identified. It is clearly referable to the Dermochelyidae but differs generically from the modern leatherback turtle. Since this is the first fossil skull belonging to this family, comparisons cannot be made with two known Tertiary genera. The carapace comprises about 26 small polygonal bony plates and includes a row with a definite ridge, which indicates location along one of an unknown number of lateral ridges, comparable to those possessed by *Dermochelys*. Comparison with descriptions of *Psephophorus* von Meyer and *Cosmochelys* Andrews, both based upon bony plates, indicates closer resemblance to species of *Psephophorus* than to the Eocene genus *Cosmochelys*.

Differences between unoriented portions of carapaces may have little significance, but the Oregon skull and bony plates are questionably referred to *Psephophorus* and described as a new species.

FOSSIL AND RECENT PELECYPODS OF GENUS *CHIONE* OF WEST COAST OF NORTH AMERICA

BY PIERRE E. PARKER *

After an intensive study of the west coast forms of the genus *Chione* four sections have been erected to cover the 27 recognized species. These sections do not coincide with those of K. V. Palmer. The first section is the *securis* group in the Oligocene which has certain features of sculpture and hinge that serve to separate it from all others of the genus. The southernmost occurrence is in Ventura County Pliocene in the form of *C. elsmerensis*. From the Oligocene through the Pliocene the group occurs abundantly to the north, even being reported from Kamchatka. Great variability of form tends to limit the value of the group as horizon markers. The other three sections, typified by such well-known species as *succinta, gnidia,* and *subrugosa,* are all of more tropical distribution and probably find their origins in the Caribbean province. The first appearance of the tropical groups is in the Vaqueros of Southern California.

As a result of detailed examination of types and of newly prepared material, many fossil species have been placed in synonymy, as differences due to the effects of erosion and weathering have not been sufficiently considered by earlier workers.

OCCURRENCE OF CHINESE FELID GENUS *METAILURUS* IN PLIOCENE OF CALIFORNIA

BY KING A. RICHEY †

Skull and jaws of a large true cat in the lower Pliocene Black Hawk Ranch fauna, Mt. Diablo, show similarity amounting almost to identity of species with *Dinofelis abeli* Zdansky from the Pliocene deposits of Honan Province, China. The Californian material gives evidence that *Dinofelis* is probably congeneric with another North Chinese genus, *Metailurus* Zdansky. The discovery brings to light another example of extensive migrations of certain large land mammals across the Behring land bridge in Pliocene time. The practice of automatically applying different generic and

* Introduced by B. L. Clark.
† Introduced by Chester Stock.

specific names to fossil mammals of same type in North America and Eurasia does much to obscure the closeness of relationship which in some instances may amount to identity of species.

RENAMING PRIMARY HOMONYMS AFTER GENERIC REALLOCATION

BY HUBERT G. SCHENCK AND A. MYRA KEEN

Should a primary homonym be renamed if either of the species involved is transferred to another genus? The problem, in other words, is: *X-us albus* Doe, 1840, is a primary homonym of *X-us albus* Smith, 1837, but the species of Doe was transferred to the genus *Y-us* by Brown in 1925 and has since been known as *Y-us albus* (Doe), 1840. Must a systematist who discovers in 1941 that *X-us albus* Doe was a primary homonym rename the species despite the generic reallocation?

From among many examples that might be cited the following are selected: (1) *Nucula phillipsii* Morris, 1850 (NOT *Nucula phillipsii* Von Hagenow, 1842), a Jurassic species transferred to *Palaeoneilo* by Cox in 1937; (2) *Nucula abrupta* Conrad, 1848 (NOT *Nucula abrupta* Dana, 1847), a Tertiary species transferred to *Malletia* by Dall in 1909; (3) *Cardium spinosum* Meuschen, 1787 (NOT *Cardium spinosum* Solander, 1786), a Recent species transferred to *Papyridea* by Clench and McLean, 1937. It is assumed that for none of these species names are synonyms available.

As the International Rules of Zoological Nomenclature now read, each of these species names must be regarded as stillborn at time of proposal, and each must be replaced, even if since associated with another generic name. Evasion of the rule, in an attempt to minimize nomenclatural change, has been the practice of many workers. We therefore raise the question of whether or not an emendation of the rule on priority might be desirable.

CAMBRIAN SEQUENCE IN WESTERN GRAND CANYON, ARIZONA*

BY EDWARD T. SCHENK AND HARRY E. WHEELER

Correlation of the western Grand Canyon Cambrian strata involves consideration of formations and faunas from eastern and southeastern Nevada and from the Granite Gorge area of the Grand Canyon in Arizona. Lithologic units defined in both regions are recognized. Priority of definition is employed as the basis for acceptance of formational names.

On the south canyon wall about a mile east of Grand Wash Cliffs, 169 feet of Lower Cambrian Prospect Mountain quartzite (Eureka district, Nevada) lies unconformably upon pre-Cambrian granite gneiss. These rocks are overlain by 304 feet of Lower and Middle Cambrian Pioche shale (Pioche district, Nevada), carrying the *Olenellus* zone fauna at the base and the *Albertella* fauna near the top. Above the Pioche formation lies 70 feet of strata consisting of two massive dolomite members separated by 40 feet of sandstone, shale, and dolomite. This unit is the lithogenetic equivalent of the Lyndon limestone (Pioche district). The Lyndon is superseded by 99 feet of Chisholm shale (Pioche) with the *Glossopleura* zone fauna. The Chisholm formation is in turn overlain by about 380 to 400 feet of Muav limestone

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(Muav Canyon, Grand Canyon). All the above-mentioned Cambrian formations are conformable in the western Grand Canyon. The last three are of Medial Cambrian age.

Unconformably above the Muav limestone lies 110 feet or less of limestone of probable Cambrian age. These beds are unconformably overlain by a thick series of dolomites and limestones carrying a Devonian fauna about 1000 feet or more above its base.

UPPER PERMIAN FUSULINID FORAMINIFERA FROM AFGHANISTAN*

BY M. L. THOMPSON

Fusulinid foraminifers from Upper Permian limestones near Bamian, the locality from which Hayden obtained his collections for his report published in 1914, show the association of representatives of the genus *Polydiexodina* Dunbar and Skinner with representatives of the genera *Sumatrina* Volz, *Neoschwagerina* Yabe, *Cancellina* Hayden, *Verbeekina* Staff, *Schwagerina* Möller, and *Schubertella* Staff and Wedekind. The collecting locality is approximately 34° 55′ N. Lat., 68° 18′ E. Long. (Greenwich), about 7 kilometers westerly from the summit of Shibar Pass; collectors, H. M. Kirk, G. L. Postle, and H. G. Schenck, 1937-1938. As representatives of *Polydiexodina* are restricted to the upper portion of the Guadalupe series in America, this association in Afghanistan indicates a late Guadalupe or younger age for the limestone near Bamian.

PERMIAN FUSULINIDS FROM BRITISH COLUMBIA, WASHINGTON, AND OREGON

BY M. L. THOMPSON AND HARRY E. WHEELER

One species each of the fusulinid genera *Nankinella* Lee, *Neoschwagerina* Yabe (?), *Schwagerina* Möller, *Staffella* Ozawa (?), and two species of *Yabeina* Deprat are found in the Marble Canyon limestone (upper Cache Creek series) of Marble Canyon, Lillooet district, southern British Columbia.

A species of the genus *Yabeina* Deprat occurs in a limestone cobble from Tertiary gravels near Madras, Jefferson County, north-central Oregon.

These approximately contemporaneous British Columbia and Oregon fusulinid faunas are closely related to similar faunas from Eurasia and northern Africa. However, no fusulinid from the Marble Canyon and Oregon collections is conspecific with any described species from the Permian of other areas in the Americas.

The only fusulinid previously described from the Cache Creek series was originally designated *Loftusia columbiana* Dawson but later was referred to the genus *Neoschwagerina* Yabe. *L. columbiana* is here referred to the genus *Yabeina* Deprat. Thus *Yabeina*, which is present at both the Marble Canyon and Madras localities, is recognized in North America for the first time.

MIOCENE SEA-COW FROM SANTA CRUZ, CALIFORNIA, AND ITS BEARING ON INTERCONTINENTAL CORRELATION

BY V. L. VANDER HOOF

Preliminary studies of the principal parts of the skull and skeleton of a dugongid sirenian from Bean Creek north of Santa Cruz, California, indicate that it is the

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same species as certain remains from the Upper Miocene of the Vienna Basin. The specimen now at the University of California was found in coarse sands 50 feet above an unconformable contact with siliceous shales and 240 feet below a zone of *Astrodapsis* cf. *californicus*. The present sea-cow is tentatively identified as *Metaxytherium petersi*, the type of which came from the "Zweite Mediterranische Stufe." *M. cuvieri* from Tours near the Gulf of the Loire in France is an ancestral species and is Helvetian. This suggests a Tortonian age for our California form. *M. jordani* Kellogg from the diatomite of Lompoc may turn out to be *M. petersi* also. Sea-cows are widely distributed littoral marine mammals capable of migrating great distances during the lifetime of a single individual. Hence they probably indicate synchrony in correlation rather than homotaxis, especially if it can be shown that a well-known European form is the same species as one from western North America. It is further suggested that the Santa Cruz specimen is in the direct line of ancestry of the recently extinct Steller sea-cow (*Hydrodamalis*) of the Bering Sea.

OLIGOCENE SEA-COW REMAINS FROM EAST COAST OF BAJA CALIFORNIA

BY V. L. VANDER HOOF

Among the incidental finds of the recent Scripps Institution expedition to Baja California was a pair of teeth of the rare sirenian mammal *Cornwallius*. The *Cornwallius* teeth indicate an upper Oligocene age in view of the fact that the only other recorded occurrences are in Sooke beds from Vancouver Island, British Columbia. Thus we see an extension of range of *Cornwallius* from Lat. 48° N. to Lat. 25° N. and a positive correlation of a British Columbia level with one in Lower California. The teeth were found in a hard sandstone in the vicinity of the San Carlos Bay area. This is the northernmost outcrop of the "Monterey" of Darton 1921. Invertebrates collected by Darton were determined by Julia Gardner as "probably Vaqueros." (Geological Society project.)

PRELIMINARY STUDY OF FAUNA OF RAMPART CAVE, ARIZONA*

BY ROBERT W. WILSON

Rampart Cave occurs in the Muav limestone of the lower Grand Canyon of the Colorado River, 50 miles airline from Boulder City, Nevada, and 5 miles above Pierce Ferry. Its elevation is approximately 1750 feet and 580 feet above the present level of Lake Mead. The floor of the cave is a nearly even surface of dung which in places is 6 feet or more in thickness. Test pits have been sunk through this material, and the present report describes the vertebrate remains uncovered in these excavations. Favorable conditions under a dry climate permitted the preservation of skin, hair, tendons, claw and horn sheaths, dung, and osseous material.

Twelve types of vertebrates are recognized in the fauna. Among the mammals found at this locality, those foreign to the region are *Nothrotherium*, *Oreamnos*, *Equus*, and *Marmota*. *Lepus*, *Felis*, *Lynx*, *Bassariscus*, and *Ovis* are all genera that are represented by species living in the region today. The environment at Rampart Cave during the period of accumulation of the organic remains seems to have been essentially that of today.

* Presented by permission of the Director, National Park Service.

ABSTRACTS OF THE SOCIETY OF VERTEBRATE PALEONTOLOGY

DECEMBER MEETING AT BOSTON

MODERN TECHNIQUES IN THE STUDY OF TERTIARY CONTINENTAL SEDIMENTS

BY JOHN CLARK

Early stratigraphic work in Tertiary formations was limited to faunal correlation and brief, macroscopic description of the sediments. During the past 20 years, various students have developed special techniques which have yielded valuable results.

Most useful petrologic data are: (1) Quartz-feldspar ratios; (2) nature, amount, and factors controlling the cementing material; (3) color, provided that the factors controlling it can be determined; (4) nature of the heavy minerals; (5) gradations in maximum grain size. Special methods of sampling are necessary in order to obtain uniform results.

Paleogeographic interpretation must at all times accompany faunal and petrologic studies. Local variation in facies is so extreme that without determination of the environment of deposition, correlation and interpretation become impossible.

FUNCTION OF THE FORELEG IN AMPHIBIAN LOCOMOTION

BY F. GAYNOR EVANS

Experiments with *Amblystoma opacum* indicate that the forelegs play a more important role in normal locomotion than is usually believed. Animals with the hind legs immobilized still showed fairly good forward locomotion accomplished by pulling with the forelegs and lateral undulations of the body. With the posterior part of the body supported off the substratum locomotion approached the normal. Immobilization of the forelegs rendered forward movement almost impossible, while immobilizing both pairs of legs prevented it in spite of violent lateral undulations of the body.

In normal locomotion the propulsive phase in the forelegs consists of a pulling action, produced by flexion of the various segments of the leg, while extension occurs chiefly during the recovery phase when the foot is off the ground. Some extension also occurs at the end of the propulsive phase just before the foot leaves the substratum. Experiments with *Triturus granulosus* show the pulling power of the foreleg is greater than supposed.

The carpal joints of the Caudata are syndesmoses with the entire region very flexible because of the elastic tissue between the bones. Flexion and extension occur chiefly at two places—(1) between the forearm bones and the proximal row of carpals and (2) between the distal row of carpals and the metacarpals. The same conditions were presumably true in the Stegocephalia.

The antero-internal region of the palm is the chief weight-bearing part of the hand. This also seems to have been true in the Stegocephalia as in many cases the tracks of the manus are deepest in this region.

RELATIONSHIPS OF THE TRIASSIC REPTILE *TRILOPHOSAURUS*

BY JOSEPH T. GREGORY

The University of Texas has obtained an articulated skeleton and numerous other specimens of *Trilophosaurus buettneri* Case from the Upper Triassic Dockum

formation in Howard County, Texas. Important morphological features of this reptile are: edentulous premaxillaries and symphysis of the lower jaws; an average of 14 transversely elongated, three-cusped, thecodont teeth on each maxillary and dentary; vertical tooth succession which progressed regularly from front to back of jaws; large laterally directed orbits; superior temporal fenestrae; elevated quadrate recurved at its upper end like that of *Diadectes* and chelonians; quadrate exposed on lateral surface of skull and supported throughout its length by the unfenestrated postorbital region; braincase unossified anterior to sella turcica; tubera and basipterygoid processes deep; 7 procoelous cervical vertebrae with paired hyposphenes; long cervical ribs; 17 amphiplatyan dorsal vertebrae with thin, crescentic intercentra and low neural spines; numerous abdominal ribs; two strong sacral vertebrae; a long tail with elongate procoelous vertebrae; girdles with expanded ventral elements; limb bones slender; humerus with expanded ends and twisted shaft; femur with strong internal trochanter; feet large, pentadactyl, lizardlike, with strong compressed claws; tarsus with navicular; fifth metatarsal "hooked". Structure of vertebrae, girdles, and limbs suggests that the animal was quadrupedal and lizardlike in body form. Adults about 2 meters long.

Numerous similarities between *Trilophosaurus* and the diapsid reptiles are due to parallel evolution from a common protorosaurian ancestor. *Trilophosaurus* is provisionally referred to the Protorosauria.

FISHES FROM THE DEVONIAN OF ARIZONA

BY L. HUSSAKOF

During the past few years, Devonian fish remains have been discovered at several localities in Arizona. The present paper is the first systematic description of this material. The specimens consist of single plates of Arthrodira, most of them of small forms, ptyctodont dental elements, and teeth of *Dipterus*. The present study is based on a small collection of such material made by Mr. L. F. Brady of the Museum of Northern Arizona, from the Mt. Elden formation, near Flagstaff, Arizona. On the evidence of the fishes, the age of the fish-bearing strata of this formation appears to be early Upper Devonian.

Among the Arthrodira studied are a few fragmentary plates of a *Dinichthys* of medium size, ornamented with small, occasionally stellate, tubercules; and a new species of *Coccosteus*, represented by isolated, single plates from different parts of the body. The ventral armor of this *Coccosteus* was reconstructed. It presents an unusual feature in having the posterior ventrolateral plates united medianly in almost a straight line, not by overlap flanges.

Ptyctodont dental elements are comparatively numerous, most of them forms with a very narrow tritor preceded by a trenchant margin. A new species of *Ptyctodus* is described.

NEW PYCNODONT FISH FROM THE UPPER CRETACEOUS OF ARKANSAS

BY L. HUSSAKOF

The species is described from two nearly complete mandibulars from the Marlbrook marl (Upper Cretaceous) of Arkansas. The principal teeth consist of a single series of narrow elliptical teeth, characteristic of the genus *Anomoeodus*. The two specimens are both right mandibulars, from two different fishes. They show that variation occurs within the same species in the row of very small teeth in

the symphyseal line: in one specimen there is a single row of very small teeth; in the other there is, beside this row, a second, more irregular series of somewhat larger teeth.

This pycnodont occurs along with shark teeth of various species, and teleostean bones and teeth, among the latter being large, slender laniary teeth of *Enchodus*. This fauna of large fishes indicates open-sea conditions; and the presence of two teeth of a trigger fish (Balistidae) indicates a warm sea as the habitat of these pycnodont fishes.

Specimens in the possession of their collector, Mr. C. M. Barber, Hot Springs, Arkansas.

PALEOPSEPHURUS WILSONI, A NEW POLYODONTID FISH FROM THE UPPER CRETACEOUS OF MONTANA, WITH A DISCUSSION OF ALLIED FISH, LIVING AND FOSSIL

BY ARCHIE MAC ALPIN

The osteology of *P. Wilsoni*, n. gen., n. sp. is described and figured. Many comparisons are made between its structures and the supposed homologues of modern and fossil fish, especially of living paddlefish and sturgeons and of *Crossopholis magnicaudatus* (the only other known fossil paddlefish) from the Eocene. The material from the University of Michigan collections consists of three close-lying individuals showing (1) a well-preserved head with jaws, branchial and hyoid arches, pectoral girdle, pectoral fins, and some minute denticles; (2) part of a caudal region; (3) part of a shoulder girdle and pectoral fin. The species has a long rostrum, fenestrated cranial roof skeleton with numerous occipital plates, and a strong parasphenoid. The mouth apparatus consists of a sturdy, posteriorly directed hyomandibular, a pterygoid with an ectopterygoid process meeting a similar process from the maxillary, a quadratojugal, a maxillary and a dentary joining anteriorly with their fellows, a prearticular, and possibly several thin palatines. The strong dermal shoulder girdle has an interclavicle. Pectoral fin rays are distally segmented, not dichotomous. The trunk is covered with spinous denticles, 0.20 cm to 0.25 cm long, not in contact. Caudal fulcra and caudal oat-shaped scutes are present. A macroscopic comparison of polyodontid squamation is made. Special attention is given to rostral and body sizes and jaw and occipital musculature with reference to feeding habits. Several undescribed features of *Polyodon* and *Psephurus* are treated. Among the suggestions offered are that (1) recent polyodontids have evolved from a line of more highly ossified ancestors, probably through some unknown palaeoniscid; (2) there is a quadratojugal in *Paleopsephurus, Psephurus,* and some sturgeons that appears to be homologous to that bone so called in the rhipidistians and lower Palaeoniscidae; (3) *Pholidurus disjectus* be removed from the family Polyodontidae; (4) the mouth of *P. Wilsoni* was protrusible; and (5) the length of the rostrum in comparison to the total body length exhibited by modern paddlefish had already been attained in the family by Upper Cretaceous time.

ANALYSIS OF *MERYCOIDODON* SKULLS

BY FRED B PHLEGER, JR.

One hundred fifty-five skulls of *Merycoidodon culbertsoni, M. periculorum, M. affinis,* and *M. gracilis* have been measured, and the skull dimensions analyzed with the following results:

Calculation of the Pearson Coefficient of Variation for the various dimensions of the skulls of the four species of *Merycoidodon* has demonstrated that these fossil species show only slightly greater relative variation than modern species. Some portions of the skull may vary independently of the rest of the skull, within limits. Actual variation of the skull characters of the species has been studied by means of frequency curves of the measurements. Overlapping ranges between the species is clearly indicated, and the frequency curves have been a convenient tool for assigning questionable specimens to their proper species. A relative growth analysis demonstrates that many of the skull ratios tend to cluster around an isogonic ratio. The most markedly heterogonic ratios are found in a comparison of posterior and anterior palatal widths.

On the basis of morphology, from stratigraphy, and from the relative growth analysis, it is strongly suggested that *Merycoidodon gracilis* is the stem species of the genus. The other species have evolved from it or from a very similar form mainly by accumulation of mutations for increase in size. Most of the relative growth ratios tend to cluster around corresponding values for the genus and family.

RESTORATION OF THE SKULL AND BRAIN OF A JURASSIC MAMMAL

BY GEORGE PINKLEY

Mesozoic mammals have been recognized as such for more than a century and a quarter, and the first specimen was obtained still a half century earlier. But due to the rarity and fragility of the remains our entire knowledge of these animals has been derived from fragmentary jaws and teeth plus a few other bits of bone, with the exception of several more or less nearly complete skulls found in Upper Cretaceous formations of Mongolia during 1924-1925. Further knowledge of earlier forms seems especially desirable since mammals existed from the late Triassic through nearly 100 million years of Mesozoic time as well as the succeeding 60 million years of the Cenozoic. From approximately the first half of that immense span of time the complete form of not a single mammalian skull is known.

By a careful study of skull fragments in the British Museum (Natural History) a restoration has been made of the skull and the gross form of the brain of a late Jurassic mammal. It represents essentially a young specimen of *Triconodon mordax* from the Purbeck formation of England, but to the extent that supplementary information was used it may be regarded as a generalized triconodont mammal. Although the animal was little larger than a mouse, there is a surprisingly carnivore-like appearance together with a reminiscent suggestion of the cynodont mammal-like reptiles. The brain appears to have been more generalized and primitive than that of any living mammal.

MARSLAND FORMATION

BY C. BERTRAND SCHULTZ

The Marsland formation of the Hemingford group of the Miocene has now been traced from the type area southwest of Marsland, Nebraska, in sections 23 to 27, T. 28 N., R. 52 W., and sections 19 and 30, T. 28 N., R. 51 W. to the adjoining States of Colorado, South Dakota, and Wyoming. The Marsland is a distinct lithologic unit in the Nebraska and Wyoming areas, and, although in Colorado and South Dakota these deposits are less typical, the faunas are equivalent. Large mammalian faunas have been collected from the Marsland formation and have been

partially studied. Extensive fossil quarries of Marsland age have been worked at Bridgeport, Marsland, and Hemingford, Nebraska.

In northeastern Colorado the Marsland is represented in part by the upper portion of the "Martin Canyon beds", while in South Dakota it is correlated in part with the "Upper Rosebud." In Nebraska and Wyoming, the Marsland includes all the deposits formerly called "Upper Harrison."

Certain deposits near Agate, Nebraska, recently suggested as intermediate between the Harrison and the Marsland are considered to be contained within the Marsland formation since these deposits can be traced directly into the type section area of the Marsland and since the faunas are also similar.

NEW MODEL OF A HOODED DUCK-BILLED DINOSAUR

BY C. M. STERNBERG

A recently completed model of the head of *Corythosaurus*, ⅓ natural size, is fairly broad with bulbous hood. Measurements were taken from a fine uncrushed skull, and special attention was paid to detailed proportions. A section was cut from the hood to show the modified, extended, winding narial tubes. The nostrils are far forward, and the mouth opens back to the front of the tooth magazine.

LARGE ARTHRODIRAN FISH PLATE FROM THE ENFIELD FORMATION (UPPER DEVONIAN OF CENTRAL NEW YORK)

BY JOHN W. WELLS

This includes a description of a very large and nearly complete median dorsal plate of the arthrodire *Holonema rugosum*, with which are associated undetermined fragmentary plates from the same individual. It is nearly identical with the median dorsal originally described by Agassiz as *Holoptychius omaliusii* from the lower Middle Devonian of Belgium and since unrecognized.

WYOMING EOCENE CORRELATION

BY HORACE ELMER WOOD, 2ND.

The Powder River Basin, long mapped as largely "Wasatch", is reinterpreted as almost entirely Paleocene ("Fort Union"), overlain by isolated patches of Lower Eocene Wasatchian. Berry's "Green River flora of the Wind River Basin", chiefly from Tipperary, is assigned to the Lost Cabin member of the Wind River formation. The apparent isolation of the Eocene sequence near Duncan, in the northwestern part of the Wind River Basin, becomes less marked. The Indian Meadows should be regarded as the basal member of the Wind River so that the Wind River formation would, in its upper members, correlate with the Knight, the typical nucleus of the Wasatch group, as well as with the Gray Bull, which contains the so-called typical Wasatch fauna, unrepresented in the type Wasatch. Uintan deposits are much more widely distributed in central Wyoming than previously supposed: they occur on the rim of Bates Hole, southwest of Casper, and, as Lysite Mountain, lie, horizontally, virtually on top of the southern hook of the Bighorn Mountains. (Geological Society project.)

OSTEOLOGY OF THE SKULL OF *AMPHISBAENA EWERBECKI* (WERNER)

BY R. ZANGERL

The skull morphology of a very small recent amphisbaenid, *A. ewerbecki* from the Tanganyika Territory, East Africa, was worked out by means of a plastic reconstruction method.

ABSTRACTS OF SECTION E, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

DECEMBER MEETING AT DALLAS

EARLY MAN IN EASTERN MISSOURI

BY ROBERT MC CORMICK ADAMS

Investigations conducted by the Academy of Science of St. Louis and the W. P. A. uncovered evidences of early man in eastern Missouri at the large Hidden Valley rock shelter 30 miles south of St. Louis and a mile from the Mississippi. The rock shelter lies at the base of Saint Peter sandstone.

Beneath the center of the shelter under a late fill containing evidences of late Indian occupation where pottery was more common than stone implements was found a clearly marked gully channel containing 75 projectile points, most of them broken, of several different forms but only 2 fragments of pottery in secondary position. Typologically these points have their counterparts in known early components of the Woodland Pattern in the Mississippi Valley—*viz.*, small concave based points, a small channeled form, and large side-notched points. The gully was formed during a heavy rainfall period.

On either side of the gully area were discovered evidences of an intact early silt fill lying under the later fill. No pottery fragments and very few fragments of bones were found. The chipped stone implements were similar to those from the gully area.

The earliest implements were found imbedded in the loose original sand floor and preceded both the shelter fill and the rainfall period that caused the gully. They were mainly finely chipped long tapering points with elongate S-shaped profiles without pottery associations. The earliest culture-bearing strata had a low organic content, and animal bones had completely disintegrated.

RECHARGE TO GROUND WATER FROM FLOODS IN A TYPICAL DESERT WASH, PINAL COUNTY, ARIZONA*

BY H. M. BABCOCK AND E. M. CUSHING

Floods on Queen Creek were studied to determine the amount and rate of recharge to ground water from floods, the probable effect of flood control on ground-water recharge, and the flow that would give maximum recharge and minimum waste. Two fully equipped gaging stations were installed—one where Queen Creek enters the desert plain, the other 19 miles downstream.

Measurements of 17 separate floods were studied, and the average rate of infiltration was found to be about 1 acre-foot of water per acre per day. Seepage measurements were made during steady flows of clear water after two large floods. The average rate of loss for the entire reach between gaging stations was about 4½ acre-feet per acre per day. This rate is much greater than for floods, probably due to the heavy silt load carried during flood periods. Near the upper gaging station after floods the rate of infiltration increased as a result of the clear water agitating the stream bottom and thus picking up the fine material and leaving the coarser, more permeable material. When there is sufficient flow to cause water to pass the lower gaging station, this fine material is carried below the recharge area and deposited. When the flow is too small to pass the lower station, the silt is deposited in the creek channel.

* Published with the permission of the Director, Geological Survey, U. S. Department of the Interior.

During the period of this investigation about 32,000 acre-feet, or about half of all the water passing the upper gaging station, seeped into the ground-water reservoir. A flood control dam would enable practically all this flow to be diverted underground.

STRATIGRAPHY AND STRUCTURE OF THE CONFUSION AND CONGER RANGES, WESTERN UTAH

BY CHARLES S. BACON, JR.

A thick section of Paleozoic sedimentary rocks, topped by Lower Triassic, comprises the bulk of the Confusion and Conger ranges. The 13,000 feet of section measured to date includes Lower Triassic to Lower Mississippian beds, and below this lies a thick section of older Paleozoic sediments which further study will probably reveal as complete down to the Upper Cambrian of the House Range. Predominant are limestones, with cherty zones very abundant, but considerable sandstone occurs in the Pennsylvanian. Shales are scarce but fossiliferous.

A rich ammonite fauna was collected from the Lower Triassic, good brachiopod assemblages from the Permian and Pennsylvanian, and crinoids and goniatites from the Mississippian. Fossils, such as a few gastropods and corals, were obtained from the older beds.

The structure is essentially a series of folds with subparallel, sinuous axes predominantly of north-south trend, and ruptured in places along overthrusts. As a result of differential erosion the region is characterized by long, hogback ridges, and the drainage lines are well adjusted to the structure. The striking similarity of numerous isolated rhyolite porphyry and tuff exposures suggests fairly widespread coverage by relatively late flows and ash beds.

SOUTHWESTERN GEOLOGY: FEATURES AND PROBLEMS

BY CHARLES LAURENCE BAKER

Of dominant influence in southwestern geology has been the positive area or persistent platform which is the southwestern prolongation of the pre-Cambrian shield with its bordering geosynclinal areas. A number of the major problems are outlined. More investigation is necessary, and more important geologic problems await solution in the Southwest than in other North American provinces. Consequently, it should be the center of greatest interest and activity.

CRETACEOUS OVERLAP ON THE LLANO UPLIFT OF CENTRAL TEXAS

BY VIRGIL E. BARNES

Geological mapping of Gillespie County, Texas, situated on the south side of the Llano uplift, has revealed much about the topography of the pre-Cretaceous surface and about Lower Cretaceous stratigraphy. The arching and uplifting of the Llano area took place previous to the inception of Lower Cretaceous sedimentation, and little, if any, tilting accompanied the encroachment of the Cretaceous sea. The uplifted area developed considerable relief, as evidenced by high pre-Cretaceous hills now surrounded by Cretaceous sediments and by conglomerate-filled Cretaceous valleys.

Basal Cretaceous sand (Travis Peak formation) flanks the uplift and is a shoreward facies of the Glen Rose limestone. Walnut clay, and Comanche Peak limestone. The base of the flint-bearing Edwards limestone probably marks the first complete overlap of the Llano uplift by Cretaceous sediments. Locally the Travis Peak

formation contains red beds ("Gillespie formation") derived from red Cambrian sandstone. The red beds are at different stratigraphic levels, depending upon the location of the sandstone from which they were derived. The name "Gillespie formation" is, therefore, superfluous.

ZONAL AND INTRAZONAL LAND-USE DIVISIONS OF THE SOUTHWEST

BY CLYDE J. BOLLINGER

Since replacement of the natural plant cover by cultivated crops is perhaps the most fundamental geographical change resulting from man's use of the earth, the percentage of the total landscape in crops provides a criterion for land-use classification. Using 25 per cent crop-land as the limiting criterion for farming areas, and appraising the surviving remanents of natural vegetation according to their actual or potential use there emerge three major land-use zones in the Southwest: (1) a western grazing zone, (2) a central farming zone, and (3) an eastern timberland zone. These land-use zones represent a more or less stabilized adjustment to climate including associated zonal differences in natural features induced primarily by the climatic conditions under which they evolved. County percentages of cropland in 1929 were plotted, and isorithms of 50, 25, and 12½ per cent cropland were drawn. These isorithms were then adjusted to conform with actual cropland distribution as indicated by relevant natural and cultural distributions. The farm zone was divided by the 50 per cent cropland isorithm into superior and inferior subdivisions, the latter being further subdivided according to natural vegetation into woodland-pasture and grassland-pasture farm types. The grazing and forest zones were similarly divided by the 12½ per cent cropland isorithms into range-ranch, ranch-farm, timberland, and forest-farm areas. Numerous areas in which land-use distribution conforms to intrazonal edaphic conditions appear on the map, notably farming districts in the forest zone, ranching and ranch-farming districts in the farm zone, and irrigated districts in the grazing zone.

FOSSIL MAN IN SOUTHERN CALIFORNIA

BY A. O. BOWDEN AND IVAN A. LOPATIN

The workers of the W. P. A. Project (C-642) unearthed some human bones while digging a storm drain on January 23, 1936, near the cross section of Moynier Lane and Higuera Street on the outskirts of Los Angeles. A skull and other human bones were excavated in a gray, sandy clay, 12 to 13 feet below the surface. A little later four teeth and small fragments of bones of a mammoth, *Archidiscodon imperaton* (Leidy), were unearthed at the same depth and in the same stratum.

According to Dr. T. Clements, Chairman of the Geology Department of the University of Southern California, the deposits containing the human remains were laid down by the stream that beveled the lower Pleistocene marine sediments and are late Pleistocene. They are probably the equivalents of the Rancho La Brea and Centinela Park deposits, and the human remains are of the same age.

The human remains consist of a cranium and of seven fragments of other bones. The whole facial skeleton of the cranium is lacking; only the posterior portion of the calvaria is present.

The skull is acrocranial, its maximum breadth being 134 mm., casion-Cregma height 132 mm., auriculo-Cregmatic height, 107 mm. It belonged to an elderly female individual. It is difficult to identify the physical type. The cranium exhibits no striking primitive features and seems to belong to *Homo sapiens.*

STRATIGRAPHY OF THE UPPER CAMBRIAN, LLANO UPLIFT, TEXAS*

BY JOSIAH BRIDGE AND VIRGIL E. BARNES

This paper discusses the correlation of various members, a number of new member names for various well-defined lithologic units.

In many parts of the uplift the Wilberns formation can be divided into four members—a basal sandstone, a lower glauconitic limestone, a green calcareous shale, and an upper limestone. The basal sandstone is not present in all parts of the uplift. Both it and the lower portion of the lower glauconitic limestone carry the *Camaraspis* fauna. The lower limestone and the shale member carry the conaspid faunas, and the upper limestone carries many of the faunas from the *Ptychaspis-Prosaukia* zone to the *Plethopeltis* zone. Geologic mapping in Gillespie County by Barnes and paleontologic studies by Bridge show that Cambrian dolomites in the northeastern and eastern parts of the uplift, formerly mapped as Ellenburger and believed to be younger than the youngest members of the Wilberns, are actually equivalent to a portion of them.

MEXICAN POPULATION IN SOUTHWESTERN UNITED STATES

BY ELIZABETH BROADBENT

In 1930, the only year in which a United States Census enumerated Mexicans as a separate group, the Mexican population of Texas, New Mexico, Arizona, and California totaled 1,225,207, or 86.2 per cent of all Mexicans in the United States. In these States, Mexicans represented 9.9 per cent of the total population.

Prior to 1910, measured by the Census data concerning persons born in Mexico and resident in the United States, these States contained over 97 per cent of all Mexican population in the United States. Demand for labor in industries, deprived of man power during the World War and of much immigrant labor by the 1920 Immigration Laws, stimulated Mexican immigration to the northern Great Plains and to the industrial East. The Southwest also increased in Mexican population but became in addition a reservoir of floating Mexican population intending to move farther north.

The pattern of pre-war Mexican population in the Southwest showed no greater concentration than that for the population as a whole. After the war, however, the enlarged Mexican population became concentrated in newly developed agricultural areas growing cotton, citrus fruits, and sugar beets and in railroad-construction and fruit-canning centers. Five areas, centering around Los Angeles, El Paso, San Antonio, Corpus Christi, and the Lower Rio Grande Valley, contained in 1930 39 per cent of all Mexicans in the United States, and over 70 per cent of all Mexicans in the Southwest.

RECHARGE AND DISCHARGE OF THE GROUND-WATER RESERVOIRS ON THE HIGH PLAINS IN TEXAS

BY W. L. BROADHURST

The High Plains in Texas, occupying about 35,000 square miles, are bounded in most places by escarpments several hundred feet in height. About 250,000 acres of this area are irrigated with water from wells in the Ogallala (Tertiary) formation, which lies at or near the surface and in many places is between 200 and 300 feet thick. The water-bearing sands of this formation are cut off in all directions from

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any underground connection except through the underlying older rocks which contain highly mineralized water entirely unlike the fresh water in the Ogallala. The source of the water, therefore, must be the rain that falls on the surface of the Plains. Before pumping was started the underground reservoirs were in approximate equilibrium; the average annual recharge was balanced by an equivalent average annual discharge. By drilling test holes and by observing water levels in wells, it was shown that recharge occurs from streams, depressions in which storm water accumulates, and areas covered by sand dunes. Most of the natural discharge occurs through seeps and springs along the eastern escarpment and in places in the High Plains where the streams have cut below the water table. Measurements and estimates of the natural discharge were made along a 75-mile stretch of the eastern escarpment and in an area of 9000 square miles of the Plains to the northwest. The natural discharge amounted to only about 25,000 to 30,000 acre-feet a year, and this is presumably also the average annual recharge. Records of annual pumpage are compared with decrease in storage, as indicated by the decline of the water table.

AGRICULTURAL USE OF GROUND WATER IN A PORTION OF THE SOUTHWEST

BY HARRY P. BURLEIGH

In the Southwest, it is probable that the largest consumptive use of ground water has been developed through efforts of the well irrigator. The farmer, as the largest user of ground water, is deeply interested in the quantities of ground water economically recoverable and in the rates at which the available quantities are being depleted through use. Agricultural and social planners have an equal interest in the quantities of ground water known to be available, as well as in the quantitative possibilities for utilization of undeveloped ground-water supplies.

This paper examines in a general manner the agricultural consumptive uses of ground water in the United States in the portion of the Southwest lying west of the 99th Meridian, east of the Continental Divide, and south of Latitude 39°. The conclusion is that possibilities for expansion of agricultural enterprises that rely on well irrigation do not appear to be great.

It has been determined roughly that well irrigators in the area recovered in 1940 approximately 654,000 acre-feet of ground water. Under present economic conditions, the development of additional well irrigation probably will not exceed an annual withdrawal of more than 150,000 acre-feet above the 654,000 acre-feet now being withdrawn. It appears desirable to concentrate research efforts to studies of more effective use of water and of the response of aquifers to varying rates of extraction, particularly where water is recovered from storage.

REDLANDS OF CENTRAL EASTERN TEXAS

BY W. T. CHAMBERS

In central eastern Texas a "redland belt" extends from the Sabine River to the Neches River. Its uplands are characteristically red because their soils contain much iron. They are the most fertile and thoroughly utilized agricultural lands in that part of Texas. Most of this redland is residual upon glauconitic beds of the Weches, Reclaw, and Queen City formations which are mapped jointly as the Mount Selman in eastern Texas.

This redland area has long occupied a position of distinction and leadership in its section. Here dwelt the Tejas or Texas Indians, known as the most progressive and influential tribesmen between the lower Mississippi and the Rio Grande.

Spanish and Mexican efforts to colonize eastern Texas were centered in the redlands, and the principal road by which pioneer Americans entered Texas traversed this area. Several of the earliest Protestant churches and American schools in Texas were in the redlands. Here the first armed conflicts between Americans and Mexicans for control of Texas were centered. The population of the redlands played a conspicuous part in winning Texas independence, in establishing the Lone Star republic, and in the movement for annexation by the United States.

Although its regional leadership has declined, the development of this redland belt continues. Agriculture has profited by the construction of railroads and highway improvement. Farm products are processed in factories, and timber, mainly secured outside the redland, is made into lumber. Nacogdoches and Jacksonville, principal redland cities, are commercial, manufacturing, and educational centers. The redland population is fairly dense and progressive.

PLEISTOCENE MAN IN FLORIDA

BY C. WYTHE COOKE

In 1926 Gidley and Loomis reported the discovery at Melbourne, Florida, of a human skull, finger, arm, and leg bones near the top of a late Pleistocene deposit that has since been named the Melbourne bone bed. This bed, which contains many extinct vertebrates, probably accumulated in fresh or brackish marshes behind a barrier ridge of the Pamlico sea, which stood about 25 feet higher than present sea level.

The Pamlico epoch was immediately followed by a fall of sea level to a position at least 25 feet lower than the present. This low-level stage is presumed to represent the Wisconsin glacial epoch. If this correlation is correct and if the human remains were actually in place in the Melbourne bone bed (both of which seem probable), man was in Florida before the last glacial epoch.

ARTIFACT OCCURRENCE IN THE SECOND TERRACE OF THE RIO GRANDE IN STARR COUNTY, TEXAS

BY GLEN L. EVANS

Flint artifacts, including complete implements and numerous spalls or flakes, have been found in place in the second terrace of the Rio Grande near Rosita, Texas. The artifact horizon occurs about 25 feet below the terrace surface and is exposed for more than 100 feet along the face of a meander-cut bluff.

Several stages and levels of stream deposition are evident in the immediate area. Opposite the Rosita site, on the Mexican side of the river, a broad flood plain now is in the process of active alluviation. At a higher level, on the Texas side, is a remnant of the first terrace above the flood plain. This first terrace is being destroyed by lateral erosion, but its surface is still occasionally covered by unusually high floods. The second terrace, which contains the artifacts, is well developed, and its surface is well above flood level.

An almost complete lower jaw of the elephant *Parelephas columbi* was found in the river bed about 200 feet downstream from the bluff containing the artifacts. The fossil probably came from the second terrace because no older Pleistocene deposits are now being eroded at so close an upstream point, and the specimen obviously could not have withstood transportation for any considerable distance.

This artifact occurrence is noteworthy not only because of its considerable antiquity but also because it is in a well-developed terrace which can be traced along much

of the lower reaches of the Rio Grande and possibly can be correlated with coastal deposits.

ORIGIN OF SPITS, BARS, AND RELATED STRUCTURES

BY OREN F. EVANS

Building and lengthening of the superaqueous portion of a spit or bar occurs when the amount of material transported out along the shore by the swash and backwash is greater than can be moved across the submerged end by shore drifting produced by the refracted waves. If the water surface has a constant elevation the submerged part of the spit or bar is not brought above the surface by waves moving in a direction perpendicular to its axis. Such wave action results only in widening the submerged ridge. Hooks are caused by the work of refracted waves which cause transportation across the end of the spit by beach drifting. A change of wave direction or the presence of tidal or hydraulic currents is not necessary for their building although if such currents are present they may aid the process. Looped bars are built by refracted waves in the same way as are hooks. However, in the looped bar the process operates more uniformly and continues until the bar rejoins the shore. The windward end of a looped bar originates in shallow water on a gently sloping bottom. The location of the point at which the return to the shore begins depends on the depth of water, amount of sediment being carried by beach drifting, and the energy of the waves.

Extensive observations indicate that the lengthening of spits and bars takes place only when the waves move in a direction such that they cause beach drifting along the shore toward the end of the spit. Waves from any other direction cause it to be shortened and widened. (American Philosophical Society project.)

DEEP-SEATED SOLUTION IN THE MEADE BASIN AND VICINITY, KANSAS AND OKLAHOMA*

BY JOHN C. FRYE AND STUART L. SCHOFF

Sinkholes in and adjacent to the Meade basin, in Meade and Clark counties, Kansas, and Beaver County, Oklahoma, occur in an area extending eastward from two or more Pliocene faults. Some of the sinks are almost completely filled with Pleistocene deposits, and some are only partly filled. In some the filling has been partly dissected by subsequent drainage. Water under artesian pressure in the Pliocene deposits of the structural depression west of the faults probably was in contact with the faults throughout most of Pleistocene time. It is believed that some of this water moved down the fault zones and thence eastward through permeable sandstones in the Permian and possibly also through solution channels in Permian anhydrite and gypsum, which occur beneath the area at depths of 500 feet to more than 1000 feet. Where these fresh waters came in contact with beds of salt, the salt was dissolved, and the resulting collapse of overlying beds gave rise to sinks at the surface. The solution and collapse necessarily followed the late Pliocene faulting.

INDIAN SKELETAL REMAINS FROM TEXAS

BY MARCUS S. GOLDSTEIN

Skeletal remains of Indians from all parts of Texas were examined. Temporally, most of these were pre-White-Contact, some going back at least 1000 years. Morphologically, the skeletons definitely represented neanthropic man and show

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no "early" or primitive characters. Indians of southeast Gulf Coast were dolichoid (C. I. 72.0) and medium to tall in stature (168 cm.); the southwest cave dwellers were also dolichoid (70.3) but tended to short stature (165 cm.); central and north-central Texas Indians were fairly tall (168 cm.) and also very dolichoid (C. I. 70.3-71.5); the groups of these three sections of the State are considered basically of the same ethnic stock, with local differentiations. The northeast portion of the State reveals cranial deformation and prevailing meso- to brachycrany; these peoples are distinct from the preceding groups and linked to Hrdlicka's "Gulf" type of Louisiana and Arkansas.

FORTY YEARS OF OKLAHOMA GEOLOGY

BY CHARLES N. GOULD

During the last decade of the nineteenth century four men conducted geological work in Oklahoma and Indian Territory: Robert T. Hill, Joseph A. Taff, N. F. Drake, and F. W. Cragin. In 1900 the writer organized the Department of Geology at the University of Oklahoma and in 1908 the Oklahoma Geological Survey.

In this paper is traced the development of geologic science in Oklahoma, both with reference to instruction offered in the various institutions of higher learning and particularly with regard to the application of technical knowledge to the development of the various geologic resources of the State. Of these, petroleum, natural gas, asphalt, gypsum, clay products, and Portland cement are most important. Mention is made of many of the leaders of geologic thought and activity in Oklahoma during the past 40 years.

PUMPING TESTS OF THE CARRIZO SAND IN THE LUFKIN AREA, TEXAS*

BY W. F. GUYTON

The principal water supplies in the Lufkin area are obtained from wells in the Carrizo sand, which is remarkably uniform in thickness and character. Total withdrawals from the formation in this area averaged about 7,000,000 gallons a day during the first 8 months of 1941. Further development is contemplated if present studies indicate its practicability.

A series of pumping tests with observations of drawdown and recovery in water levels was made during the summer of 1941 on five wells near Lufkin belonging to the Southland Paper Mill in order to obtain data for estimating future declines of water levels in wells drawing from the formation. The results of these tests were analyzed by means of Theim's and the nonequilibrium formulas. The application of Theim's formula gives coefficients of transmissibility ranging from 31,500 gpd/ft. to 36,000 gpd/ft. and averaging about 33,000 gpd/ft. Coefficients of transmissibility determined by the nonequilibrium formula range from 30,600 gpd/ft. to 34,100 gpd/ft. and average about 32,000 gpd/ft. Coefficients of storage range from 0.00012 to 0.00016 and average about 0.00014.

Near the end of the tests the paper-mill wells were shut down for a week. The resulting water level recoveries in these wells and in outlying observation wells, and the drawdowns caused by the resumption of pumping, agree closely with theoretical recoveries and drawdowns computed by means of the nonequilibrium formula, using the average coefficients of transmissibility and storage determined from the pumping tests.

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PALEO-INDIAN IN ALASKA

BY FRANK C. HIBBEN

In the field season of 1941 the University of New Mexico expedition to Alaska spent 3½ months in a reconnaissance of the evidence of the first entrance of Early Man into North America. Two areas were intensively studied: Cooks Inlet and the mainland immediately adjacent to the north, and the lower Yukon Valley especially in the vicinity of Koyukuk. The survey involved the paleontological examination of the Alaskan "muck" cut through in gold mining operations. The muck deposits, from 4 to 100 feet thick, are composed of fine silt derived from the underlying bedrock (schist). The muck is perennially frozen 3 feet below the surface and is further characterized by lenses of pure ice, peat strata, volcanic ash layers, and an abundance of disarticulated mammal bones of bison, horse, mammoth, mastodon, lion, wolf, bear, musk ox, caribou, and moose. Evidences of man in the form of flint points of the Yuma type were found in the muck in the vicinity of Fairbanks but were unassociated with any occupation level. A well-established site was found at Chinitna Bay on the north side of Cooks Inlet. In this site two points of Folsom-like type were found in place. The habitation level was stratified beneath a 10-foot thick layer of muck and an equal thickness of peat. Evidences of the Paleo-Indian of the late Pleistocene or Early Recent times are present in Alaska, but scattered, and not yet referable to definite cultures.

PRIMITIVE CULTURAL PATTERNS OF THE INTERMONTANE SOUTHWEST AS CORRELATED WITH ITS NATURAL REGIONS

BY J. W. HOOVER

The Amerindian culture culminated in the arid and semi-arid Southwest. This paper emphasizes the diversity of cultural types in this general region and their adjustments to environmental factors in a variety of natural regions.

Primitive cultures are more directly conditioned by environment than are more complex cultures, because of more direct dependence upon the environment. Two other sets of influences may be important in determining the cultural set-up: those of ethnic origin, and the cultural techniques which determine extent and manner of realizing potentialities of a region.

Cultural elements of ethnic origin and techniques acquired by contact with other groups may differ widely within the same geographical region. However, even ethnic stocks tend to spread along lines of least resistance, such as drainage, while cultural elements follow lines of trade. Differentiating characteristics indicative of racial stock or ethnic origin persist in the face of geographical environment. On the other hand geographical conditions are predominant in determining the economic life or manner of living.

In the Southwest occurs a succession of very different cultures in the same regions, each in turn based upon a more effective utilization of land. On the Colorado plateaus, two distinct types of culture are represented by the Hopi and Navaho modes of life: dwellers in compact villages, depending primarily upon farming, in contrast with semi-nomadic sheep herders. The acquisition of common techniques is gradually leveling the traditional differences between these cultures, and they are heading toward a common adjustment.

APPRAISAL OF THE FOLSOM AND YUMA PROBLEM

BY EDGAR B. HOWARD

The Folsom and Yuma problem has been complicated by the inclusion in these groups of many types of projectile points which do not belong to them. New definitions for Folsom and Yuma points are becoming recognized in which the use of a generic term, such as "fluted points" for Folsom and the tentative term "parallel-flaked" for Yuma, eliminates some of the confusion.

So few buried sites of these complexes occur that the time relationship has not been unraveled completely. At present Folsom appears to be earlier, although there may be a late overlap with Yuma. The typical Folsom so far occurs in association with *Bison taylori*. A larger type of point, quite like the fluted points from Ohio and other surface sites, occurs with the mammoth, as at Dent, Colorado; Clovis, New Mexico; Miami; and Texas. Whether this difference in type is functional or represents a time difference is not yet clear.

Few sites have produced Yuma points in place. One in Wyoming throws new light upon this group by giving us a series of stemmed types, ranging from the long narrow one to a broad, knifelike type. This site confirms another, earlier discovery at Scottsbluff, Nebraska. Yuma points are so far associated with the bison and not the mammoth. This new site near Eden, Wyoming, is on an 18-foot terrace which can be traced between two moraines in the Wind River Mountains.

FOSSIL MAN AND THE ORIGIN OF RACES

BY W. W. HOWELLS

Recent theories regarding the origin of the species *Homo sapiens*, and its relation to other known species of man, conflict as to the assumed evolutionary processes. Weidenreich suggests that different prototypes (*e.g.*, *Pithecanthropus* and *Sinanthropus*) progressed in parallel, through a Neanderthal stage, leading to the several races of *Homo sapiens*. Patterson and Coon suggest that some racial differences of today are due to hybridity among different human species, including *Homo sapiens*. McCown and Keith believe that *Homo sapiens* was a middle or upper Pleistocene offshoot, simultaneous with Neanderthal man, from an intermediate form such as Mount Carmel Man, with different races possibly appearing independently.

These hypotheses run counter to the usual (though less explicitly expressed) belief that the races of man are the result of evolutionary variation and radiation within a single species. This view demands absolute proof, not yet found, of *Homo sapiens* from the early Pleistocene. However, the improbability of the descent of *Homo sapiens* from other known species, or of a "Neanderthaloid" stage in his development, can be shown. The primitive features of modern man, illustrated particularly in the native Australian, indicate a separate line in cranial development, specifically distinct from Neanderthal man, and no living race is closer to the latter in form than is any other.

The evolution of living races was therefore probably a gradual radiation, indicating that as a distinct species *Homo sapiens* is as old as the other known forms.

CONTRIBUTIONS OF THE SOUTHWEST TO THE EARTH SCIENCES

BY ELMER H. JOHNSON

Features inherent in the environment of the Southwest have challenged attention since the early expeditions of the Spanish explorers. Scientific attention to the Southwest, begun during the middle of the nineteenth century, expanded into a wide

range of investigations embracing fundamental problems in physiography, earth history, regional and structural geology, nonmetallic resources, soils, irrigation, alkali, and archaeology. Though results of these researches have been found applicable outside the Southwest, their major contribution has been the laying of a foundation necessary to a fuller comprehension of the habitat features of the Southwest in relation to modern economic and cultural developments.

PERMIAN SEDIMENTATION IN WEST TEXAS AND ITS RELATION TO REGIONAL TECTONICS*

BY PHILIP B. KING

Sedimentation during Permian time in West Texas was strongly influenced by regional tectonic features. These features were inherited from older Paleozoic time and included the Marathon folded belt, a region of geosynclinal rocks that were deformed shortly before Permian time, and a foreland to the northwest in which there were contemporaneous uplifts and downwarps. Permian rocks were laid down over the foreland area. The area of sedimentation may be divided, according to the nature and structure of the deposits, into basins, platforms, and shelves, which were related to the preceding uplifts and downwarps. Deposition of limestone reefs, evaporites, and other characteristic Permian sediments was closely related to these features.

RIVER-FRONT OCCUPANCE PATTERN IN LOUISIANA

BY FRED B. KNIFFEN

As in other areas of French-settled America, the early rural land grants in Louisiana consisted of long strips fronting the streams. The strips varied in width from 5 to 20 or more arpents (roughly 1000 to 4000 feet) and extended in depth to 40 and occasionally 80 arpents (approximately 8000 and 16,000 feet, respectively).

The system was prevalent during the period of Spanish dominance, 1762-1800. With the Louisiana Purchase in 1803 the original grants were not only confirmed but they were designated as irregular sections in the superimposed American township system of land division.

Two widely divergent developments brought about alteration in the original pattern. Among the *petits habitants* the grants were constantly subdivided to provide land for growing families. This meant a narrowing of the strips to as little as 1 or 2 arpents (200 and 400 feet, respectively), at the same time retaining the 40 arpent length and the river-front position. In contrast the growth of large plantations in the early part of the nineteenth century resulted in the combining of many small holdings, tending to blot out the older pattern.

The long narrow strips with dwellings set near the stream persist along the bayous of south Louisiana. The pattern has even been extended to the township system, with the section-line road serving in lieu of a stream, and the land divided into strips to conform with the older practice.

DEMOGRAPHY OF LOUISIANA

BY JOHN S. KYSER

Since earliest occupance, Louisiana's population has increased steadily. The rate of increase was most rapid in those decades immediately following admission to statehood. The increases coincided with the change of political affiliation and with

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marked technical improvements in agricultural production at a time when rich areas of virgin soils were being exploited by cheap labor.

During the French and Spanish colonial periods the population was confined largely to the relatively well drained natural levees of the major streams in the Alluvial Bottoms, although there were significant settled areas on the terraces west of the Atchafalaya Basin. The development of the Cotton Kingdom resulted in selective settlement of the Upland Coastal Plain.

Essentially frontier fecundity has prevailed in both Anglo-Saxon and Latin Louisiana, although in recent years this has abated somewhat; the largest decreases have occurred in several Anglo-Saxon parishes.

At the maximum, negroes constituted nearly three-fifths of the total population. Their relative importance has decreased since 1830, although whites did not equal negroes until 1890; by 1940 whites were approximately twice as numerous as negroes.

The economic basis for Louisiana population increase and distribution has not remained constant. Agriculture and commerce constituted the basis during the early decades; later, lumbering temporarily achieved great stature. Exploitation of minerals has enabled selected parishes to replace losses with gains during the last decade. Industrialism and urbanism are on the increase, and continued dynamism is indicated throughout much of the State.

MARGINAL PALEOZIC SEAS OF NORTHERN ARIZONA

BY EDWIN D. MC KEE

During Paleozoic time the area of northern Arizona and southern Utah, located between the Cordilleran Geosyncline and a pre-Cambrian "positive" area to the east, was a shallow basin subject to periodic floodings from the west. Evidence consists of the eastward thinning of all marine formations in this area, of the absence of many formations represented farther west, and of the increase eastward in the size and number of erosion remnants on the pre-Cambrian surface.

Detailed studies in the region have demonstrated the nature of various features of sedimentation resulting from proximity to the "positive" area: (1) Results from transgressions and regressions of the seas are discussed with special reference to the Cambrian, Mississippian, and Permian invasions; (2) evidence of the interfingering of sediments as illustrated by different types of marine deposits within the Cambrian sediments and by the dove-tailing of marine and nonmarine types in the Toroweap formation of Permian age are presented; (3) changes in faunal and lithologic facies along time lines as illustrated by certain Cambrian and Permian formations are pointed out, and cases of the repetition at different horizons of similar environments such as aeolian, playa, and deltaic are discussed.

GROUND-WATER STUDIES IN THE SOUTHWEST*

BY OSCAR E. MEINZER

The natural waterworks that store and deliver ground water are the rock systems. Ground-water problems arise in nearly all localities, and the study of ground water involves all kinds and ages of rock formations and nearly all kinds of rock structure. The study of the natural waterworks is geology, but the study of their operation is hydraulics of a distinctive type.

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Most of the ground-water studies in the United States are made by the Geological Survey, Interior Department, in co-operation with State Geological Surveys and other State bureaus concerned with water resources. This program involves annual expenditure of about half a million dollars and the services of more than 100 geologists, engineers, physicists, and chemists. It includes nearly all the southwestern States, the largest program being in Texas and the next largest in Kansas.

The principal ground-water provinces in the Southwest are as follows: (1) the Coastal Plain and Mississippi embayment, underlain by productive artesian sands with problems of transmissibility and salt-water encroachment, (2) the Edwards Plateau and Balcones fault zone, with cavernous limestone, large springs and artesian wells, and movement of ground water parallel to the faulting, (3) the High Plains, underlain by Ogallala and younger sand and gravel with large storage capacity but variable recharge, (4) the Basin and Range Province, with valley fill that is being pumped heavily, (5) the Pecos drainage basin, formed largely through solution by ground water, with its perennial artesian supply, (6) the High Plateau, and (7) the areas of meager water supplies from Pennsylvanian, Permian, and Cretaceous formations east of the High Plains. Investigations are in progress in all these provinces, and nearly all are represented by papers in the ground-water symposium at Dallas.

SOLUTION PHENOMENA IN THE PECOS BASIN IN NEW MEXICO*

BY ARTHUR M. MORGAN

The Pecos basin in New Mexico is underlain by a great thickness of limestone, gypsum, and halite. Solution of these rocks by ground water since the end of the Tertiary has probably been the dominant factor in the development of the basin. From Fort Sumner southward to the Texas line the Pecos River appears to have been fixed in approximately its present position by the integration of north-south trains of sinks that developed on an extensive eastward-sloping late Tertiary pediment of High Plains age. In some large sections of the basin the quantity of material that has been dissolved by ground water is believed to be comparable with that removed from the surface by streams. Over 1000 feet of halite has been removed from beneath some parts of the area east of the Pecos. At present large areas of the basin are drained entirely through solution channels developed in the underlying limestone and gypsum. The water taken into these beds in the outcrop areas emerges in the Pecos River highly mineralized. The load of dissolved solids annually discharged into the Pecos River in New Mexico, exclusive of that picked up in the Carlsbad Irrigation Project, averages about 1,011,000 tons, or about 48 tons per square mile of the Pecos watershed in the State.

CARBONIFEROUS ROCKS OF THE LLANO REGION IN CENTRAL TEXAS

BY F. B. PLUMMER

The stratigraphy of the Carboniferous rocks in the Llano region is reviewed briefly. New information on the characteristics and age of the Chappel formation is presented. A twofold division of the Barnett formation and a threefold division of the Marble Falls formation are proposed. The characteristics of the various members and their facies changes are described and illustrated. New information on the structure of the region is shown by maps and diagrams. Seven distinct types of deformation are indicated. The relationship of these various structural features to each other and to the central granite mass is pointed out, and their origin is discussed.

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ABANDONED PECOS VALLEY ACROSS REYNOSA CUESTA, SOUTH TEXAS

BY W. ARMSTRONG PRICE

An abandoned valley 6 to 8 miles wide is indicated by a somewhat obscure linear depression parallel with, and 35 miles north of, Rio Grande valley. It is cut off by the Bordas scarp at Randado, Jim Hogg County, traverses the Reynosa Cuesta, and seems to end just east of the Sal Vieja salina near Raymondville, Willacy County, at the Ingleside shore line of Mid-Beaumont (Pleistocene) age.

When theoretical analysis is made of the probable topography of a valley warped gulfward on an axis at 60° to the valley and, after abandonment, somewhat modified by local valley-side erosion and eolian deposition, the result seems to agree well with the form of this linear depression and seems to explain its obscurity. The two large saline playas of South Texas lie in it.

Since the abandoned valley and the Rio Grande valley were simultaneously occupied by streams of approximately equal size, the conclusion seems indicated that the Pecos River cut the now-abandoned valley and that piracy at Laredo terminated its active life.

AMPHIBIANS FROM THE DOCKUM BEDS OF CROSBY AND HOWARD COUNTIES, TEXAS

BY H. J. SAWIN

Collections recently assembled at The University of Texas contain three new species of stereospondyls referable to the genus Buettneria. Prepared specimens of one new species include nine skulls with much associated skeletal material. These were found near Otis Chalk, Howard County, Texas, and represent a form similar to *Buettneria perfecta*. A small form about half the size of *Buettneria bakeri* is also present at a different level at this locality, this animal having well-ossified skeletal remains in association with two complete skulls. The third species was collected in Crosby County, Texas, at the upper reaches of Sandy Creek. It has a thin-boned skull which differs in proportions and dentition from *Buettneria perfecta*, although they are both in the same size range.

These three forms and the other two species known from previous descriptions indicate a radiation of aquatic amphibia which may be compared with a contemporaneous radiation of phytosaurs of the genus *Machaeroprospus*.

RECHARGE, MOVEMENT, AND DISCHARGE OF GROUND WATER IN THE EDWARDS-GEORGETOWN LIMESTONE RESERVOIR, TEXAS*

BY A. N. SAYRE AND R. R. BENNETT

The Edwards-Georgetown limestone reservoir, the most productive aquifer in Texas, supplies large artesian springs and many wells in a belt extending from Austin southwestward to San Antonio, and thence westward to Comstock, about 250 miles. East of Kinney County the Edwards limestone (Fredericksburg) is the chief aquifer. From Kinney County westward the Georgetown (Washita) thickens to several hundred feet and probably yields as much water as the Edwards. The belt lies along the landward margin of the Coastal Plain and is bounded on the north by the Edwards Plateau: as far west as Kinney County it coincides with the Balcones fault zone.

The limestones crop out on the Plateau and, because of increased southward dip or faulting, they pass beneath the Coastal Plain. The recharge from streams in Uvalde

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and Medina counties and from rainfall and streams in Kinney County amounts to several times the combined discharge of springs and wells in these counties. On the other hand, the discharge in the counties to the east is much larger than the probable recharge. Although some water moves down the dip, considerable amounts probably move diagonally, some eastward from Kinney County to San Antonio and possibly New Braunfels, and some westward to San Felipe Springs. This conclusion is supported by the facts that the piezometric surface is highest in Kinney County and becomes progressively lower toward the east and west and that south of the line of springs the limestone is relatively impermeable and the water is highly mineralized.

ODESSA METEOR CRATERS

BY E. H. SELLARDS

Excavation of the Odessa meteor craters as an educational project has been carried on continuously since September 1939. The excavation is being made by Federal, State, and County funds with some contribution from private sources. The principal results obtained to date are the following: The large meteor mass of the main crater lies at a depth of 164 feet from the surface. A "rock flour" stratum overlying the meteor, representing minutely shattered rock, reaches a maximum thickness of 25 feet. The debris that fell back into the large crater is from 10 to 15 feet or more thick. The wind-carried dust and silt and fine sand that have settled or washed into the crater since it was formed reach a maximum thickness of about 70 feet. The Cretaceous limestones penetrated by the meteors were highly folded and faulted in the crater rim. Fossils, including teeth of *Equus* sp., have been found in the crater fill at a depth of 12 to 18 feet, indicating that the meteor fall preceded the extinction of the native American horse. A small crater near the rim of the large crater is about 75 feet across and 23 feet deep. This small crater contains several thousand meteorites, making a total of several tons of meteoric iron. Many of the meteorites are deeply oxidized, the maximum oxidation observed being to a depth of 3½ inches. A shaft is being constructed to the meteor of the large crater.

TERRACE DEPOSITS AS AN AID TO AGE DETERMINATION OF EARLY MAN

BY E. H. SELLARDS

The stream terrace deposits of the Gulf Coastal Plain afford excellent record of geologic events through much of Pleistocene time. These terraces have the further advantage of being directly traceable into the Pleistocene marine and semi-marine formations of the present Gulf border. It is not too much to anticipate that upstream in some of the large rivers entering the Gulf a correlation between this terrace development and glacial periods may be established. These streams have, as a rule, exceptionally broad flood plains subject to present-day inundation, and terraces are in process of construction. Some of these flood plains, such as that of the Trinity and Brazos rivers in Texas, are sufficiently old to contain some extinct animals as fossils. Above this flood plain are remnants of successively older and higher flood plains constructed when the river had not cut so deeply as it has at present.

Developments of recent years have shown very definitely that man has been present in the Texas region through at least three stages of terrace building by the streams. In view of the amount of work done by the river to build and destroy successive valleys, it is the writer's belief that the time interval in years now com-

monly assigned to cultural stages is much too short. In any case the rivers present an impressive demonstration of work accomplished during the time that man has inhabited the region.

LARAMIDE AND LATER OROGENY IN THE SOUTHEASTERN PART OF THE WESTERN CORDILLERA

BY J. FRED SMITH, JR.

In the southeastern part of the western Cordillera, from the southern end of the Rocky Mountains through Trans-Pecos Texas and into the Sierra Madre Oriental of Mexico, the Laramide orogeny is well recognized. However, in the area as a whole less is known of the ages of the later deformations, the dating of which is difficult because of the problems of determining the exact ages of the rocks involved.

Normal faulting was dominant in the Cenozoic deformation, although some folding of the volcanics has been reported from the Davis Mountains and other areas of Trans-Pecos Texas, as has thrust faulting of the volcanics in the Tierra Vieja Mountains to the west. These volcanics are certainly Tertiary, because they rest on a surface which truncates deformed Upper Cretaceous sediments, but more specific ages have not been determined.

Studies of the Santa Fe formation (late Miocene(?)—early Pliocene) in the Rio Grande depression have proven the occurrence of basin-forming movements before the deposition of the beds, as well as the later deformation of these basin deposits.

In the Sierra del Carmen and other parts of the Big Bend area of Texas true fault scarps cut the Tertiary and older rocks. The faults forming these scarps are probably Pleistocene or later.

Studies made of the deformation in this whole region are compiled, and, insofar as it is possible, the Laramide and post-Laramide tectonic history of the area is presented.

NEW MID-CAMBRIAN PTYCHOPARID, *BRAINTREELLA**

BY ROBERT R. WHEELER

The famous *"Paradoxides* Quarry" at Braintree, Massachusetts, was obliterated in the winter of 1940-1941 during expansion of the Fore River shipyards. A final fossil collection, authorized by the U. S. Geological Survey, contains a new species related to *"Ptychoparia" rogersi* Walcott and necessitates a restudy of the latter.

"Ptychoparia" rogersi was referred by Howell and Mason (1938) to Resser's (1935) genus *Ehmania* and as such would represent a link of great importance between the Atlantic and Pacific Mid-Cambrian faunal provinces because the other species of *Ehmania* are limited to the west. However, the generically significant ocular ridges, which were unfortunately ascribed to *"P." rogersi* in Walcott's (1884) description and figure and which subsequently directed the reference of this Braintree species to *Ehmania* rather than to closely related Vermont ptychoparids, are not present in the holotype cranidium nor in any of the Braintree specimens now available.

In contrast to the broadly defined genus *Ehmania,* the Vermont genera of Howell's (1937) subfamily *Nassovinae* are so delimited as to require the description of a new genus, *Braintreella,* having its closest affinities in the genera *Vermontella* and *Champlainia.* The genotype, *Braintreella* (*Ptychoparia*) *rogersi,* and the new species, *Braintreella currieri* (distinguished by its more quadrate cranidium), differ from species of *Vermontella* and *Champlainia* in possessing broader, less tapering glabellas and cranidia.

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SOIL CONSERVATION, WITH ESPECIAL REFERENCE TO NEW ENGLAND CONDITIONS

BY HENRY R. ADAMS

The thesis of soil conservation is that soil is a natural resource fundamental to human life, which, under proper use and treatment, can be permanently maintained, but which otherwise may easily be impaired or destroyed.

The character of the soil influences both the use of the land and its susceptibility to damage. Therefore, the important soil features may be interpreted on "land use capability maps", which show the recommended intensity of use and of management or treatment required to maintain the soil under that use.

Much of New England has a dense vegetative cover, either grass or trees, which protects soil from erosion, and retards fertility depletion. Recommended management practices should maintain or improve the vegetative cover while permitting the harvesting of the current growth.

Intensive tillage, as in the Connecticut Valley and Northern Maine, presents the most difficult problem of soil protection and maintenance since it accelerates the depletion of fertility and encourages erosion. Commercial fertilizers have been used in these areas for years, but in addition it may be necessary to revise the cropping system and to install such erosion control practices as strip-cropping and terracing.

Stream bank protection is important on several New England streams. Wind erosion creates a special problem on the sandy soils in the Connecticut Valley, the Champlain section, and the coastal region.

DEVONIAN BERNARDSTON FORMATION OF MASSACHUSETTS RESTUDIED*

BY ROBERT BALK

In mapping the geology of Northfield and Bernardston quadrangles, north-central Massachusetts, for the Massachusetts co-operative geologic project, the entire outcrop area of the metamorphosed but fossiliferous Bernardston formation (Devonian) was resurveyed in 1939 and 1940. Emerson's Leyden argillite forms the floor upon which the Bernardston formation appears to rest conformably, sloping at low angles southeastward. The formation begins with several hundred feet of siliceous phyllites and thin quartzite beds, and the bulk is a succession of argillaceous phyllites. Interbedded with them are, in ascending order, a lens of impure, partly mineralized, fossiliferous marble; quartz-conglomerate lenses; and lenticular bodies of metatuff(?), rhyolite, amphibolite, and metadiabase. The exposed thickness of the series approximates 7000-8000 feet.

The fossils available in various collections have been re-examined recently by Dr. G. A. Cooper, U. S. National Museum, and one single individual, *Spirifer divaricatus,* is determinable specifically and fixes the age of the marble as Middle Devonian (Onondaga).

The Bernardston formation crops out at a few places east of the Connecticut River and close to the granitic gneiss called Pelham granite by Emerson. The writer's studies confirm the belief of Keeler and Brainard that this gneiss is pre-Carboniferous, probably pre-Onondaga. It may be pre-Silurian, for it has no evident effect upon a series of metamorphosed sediments and volcanics adjacent to the east which is believed to be the equivalent of the Clough conglomerate of New Hampshire described by Billings as of early or middle Silurian age.

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Granite dikes cutting the Bernardston formation and isograds of metacrysts in the phyllites are arranged symmetrically with reference to a large uplifted block of metavolcanics, in extreme southeastern Vermont. The block has been uplifted during two periods at least, and the latest must have been post-Onondaga.

GEOGRAPHY OF NEW ENGLAND SOILS

BY ARTHUR B. BEAUMONT

In the northern portion of New England and in the higher elevations of the southern portion the cold climate and the coniferous forest cover have caused podsols; but the best developed podsols are found on the highly quartzose soils of Cape Cod. Although glaciation was severe, the bulk of the rock material was not moved far from its original location. The soils, generally, are pedologically immature and closely resemble the parent rock material in mineralogical composition. Therefore, to know the geology of the region is to know its soils.

Granites and gneisses of southern and central New England have given rise to the large Gloucester-Plymouth group, important for general farming, and to their outwash analogues, the Merrimac-Hinckley group. From the schists and quartzites of the southern, western, and central portions have developed deep and more or less compacted soils such as the Charlton, Woodbridge, and Berkshire series, and the somewhat better Worthington, Colrain, and Calais soils where the schists are calciferous. From the Connecticut Valley Triassic have come the important Cheshire, Wethersfield, and Chicopee series. On the Champlain sediments of Vermont have developed the important dairy soils, Addison and Vergennes; and on the marine sediments of the Maine and Massachusetts coastal region, the Orono series. From limestones of western Massachusetts and Vermont have come the fertile Dover-Stockbridge group; and from calcareous shales and limestones of northern Maine the Caribou soils, famed for potato growing. Important and extensive are the organic soils of New England, on which depends the important cranberry industry of Massachusetts.

BEDROCK GEOLOGY OF NEW HAMPSHIRE

BY MARLAND P. BILLINGS

The bedrock geology of New Hampshire has been intensively studied during the last decade. As a direct result of this work colored geological maps on the inch-to-a-mile scale have been published for 18 per cent of the State, and an additional 6 per cent is covered by black-and-white maps. Field work is completed, but not published, in 10 per cent of the State and is in progress in 12 per cent of the State. The total is 46 per cent.

Ordovician (?) rocks, of sedimentary and volcanic origin, totaling 13,000 feet, are extensively exposed in the western part of the State. In the same region occur Silurian rocks, not exceeding 1000 feet in thickness. Lower Devonian rocks, largely of sedimentary origin and 5000 feet thick, also crop out in the western part of the State and extend an unknown distance to the southeast. Pennsylvanian (?) rocks are extensive in the southeast.

The late Ordovician (?) Highlandcroft magma series and the Devonian (?) pretectonic Oliverian magma series are restricted to the west, whereas the Devonian (?) syntectonic New Hampshire magma series and the Mississippian (?) alkalic, posttectonic White Mountain magma series are extensively developed throughout the State.

Knowledge of the Paleozoic history of New Hampshire has been greatly amplified. A mild Taconic orogeny affected the western part of the State, but the major orogeny was late Devonian. However, the southeastern part of the State was caught in the Appalachian Revolution. The progressive regional metamorphism has been extensively studied. The New Hampshire magma series was partly syntectonic, whereas the White Mountain magma series was post-tectonic and was intruded by cauldron subsidence. The White Mountain magma series has evolved by fractional crystallization accompanied by considerable assimilation.

FACIES CONTROL OF STRUCTURAL PATTERN IN WEST-CENTRAL VERMONT

BY WALLACE M. CADY

The structural pattern in west-central Vermont reflects movements conditioned by the original distribution of sedimentary facies. Interbedded Cambro-Ordovician limestones and dolomites grade westward into foreland sandstones and eastward into geosynclinal shales. Cambrian and early Ordovician sandstone tongues extend far to the east. Later Ordovician strata of the shale facies gradationally overlap westward across the calcareous and sandy facies and are locally unconformable on it. In the Taconic Range allochthonous Cambrian strata of the shale facies are pseudoconformable with and abnormally superposed upon the overlapping Ordovician shale. The Taconic Allochthone arrived in its present position, from a root zone at least 50 miles east of the westernmost exposures of allochthonous rock, by movements confined almost entirely to the shale facies. Later flexural folding and flat thrusting, effects of alternating competency and incompetency of the stratigraphic units of the foreland sequence, affected both the latter succession and the Taconic Allochthone. These flat thrusts were initiated by the breaking of competent beds in the flexures. Thrusting continued by stripping of competent from incompetent beds. This was accompanied by counterclockwise rotation of the thrust slices produced, around pivotal zones bordering on a foreland massif to the southwest. Thus rock cropping out in the north-south thrust slices originally extended northeast-southwest. The thrusts are concentric to the Adirondack crystallines and are cut by the Adirondack normal faults. It is probable that they were warped at the time of normal faulting and uplift of the Adirondacks.

SKI GEOGRAPHY OF NEW ENGLAND

BY ALBERT S. CARLSON

The areal distribution of towns with ski facilities in New England is characterized by (1) concentration in the mountains of northwestern Connecticut, western Massachusetts, Green Mountains, White Mountains of New Hampshire and Maine, and on the upland slopes of the central and upper Connecticut Valley of Vermont and New Hampshire; and (2) by concentration of ski facilities in a few of the many towns found within the ski belt. The latter condition is not explained entirely in terms of snow cover and slope, while the former results from the lack of suitable slopes and insufficient length of season of snow cover in southern and eastern New England.

The most important ski towns are those located adjacent to public lands, such as National or State Forests, where public funds are available to clear and maintain trails. Other ski centers owe their existence and popularity to expenditure of funds by ski clubs or summer hotel owners in search of winter business.

The largest investment in ski equipment and accommodations is found in the "snow-bowl" regions around Mt. Mansfield, Mt. Washington, and Franconia Notch. Their leadership and popularity is assured for the future because of the northern latitude, glacial cirques and/or high-altitude skiing surfaces. The geographic advantages of these sections over the remainder of New England are strengthened further by the large capital investments.

OLIVERIAN DOMES IN WESTERN NEW HAMPSHIRE

BY CARLETON A. CHAPMAN

A study of the Croydon and Unity domes sheds considerable light on the mode of intrusion of the Oliverian magma series in western New Hampshire. Each dome consists of an igneous core (late Devonian) surrounded by concentric belts of older (Ordovician ?-Lower Devonian) metamorphosed sedimentary and volcanic rocks. The foliation of the plutonic cores is primarily a flow structure as indicated by the parallel arrangement of inclusions, the parallelism between foliation and contacts, and the marked development of foliation near contacts. For the following reasons the bedding-plane schistosity of the surrounding metamorphic rocks is to be attributed to dynamo-contact effects of the magma: (1) It is confined only to the rocks immediately surrounding the igneous cores; (2) it parallels the contacts of the igneous cores; (3) the relatively flat dip of bedding-plane schistosity over large areas rules out regional compression as a possible explanation.

Several lines of evidence lead one to conclude that the numerous Oliverian domes are laccoliths: (1) The structure of each dome resembles that of a laccolith; (2) all the domes have roofs at the same stratigraphic horizon; (3) the intense folding and crumpling of the metamorphic rocks between domes indicates crowding of adjacent and isolated igneous cores; (4) laccolithic intrusion best explains the bedding-plane schistosity of the surrounding metamorphic rocks; and (5) laccolithic intrusion best explains the foliation of the igneous cores.

NEW VILLAGE OF HILL, NEW HAMPSHIRE

BY FREDERICK P. CLARK

When the people of Hill, New Hampshire, were faced with the necessity of vacating their village because of the construction of a Federal flood control dam, they determined by community action to re-establish it on higher ground. The people of the village determined to plan their new community carefully so as to secure qualities of environment, economy, safety, and convenience which their old village did not have. For aid in planning this new community, the town turned to the State Planning and Development Commission.

After a site was selected, a plan providing for an economical and extremely attractive street layout was prepared by the State planning agency and adopted by the town. The people of Hill were forward-looking and realized that, if they went about it in the right way, they might build a village which would provide such advantages as to not only save themselves money but also excite the interest of residents elsewhere in New Hampshire and in the nation as a whole.

The necessity for re-establishing the people of Hill elsewhere presented an unprecedented opportunity to demonstrate what can be accomplished through careful planning in advance of development. This experience is proving of value to other New Hampshire communities which are seeing that the use of a sound planning

procedure is not just a "nice thing to do, if we could afford it", but is something that no community can afford not to do.

The new village will be largely completed during the summer of 1941.

TECHNIQUES FOR MAKING THIN-SECTION STUDIES OF GLACIER ICE

BY MAX DEMOREST

Only within the past few years have serious attempts been made to apply thin-section techniques to the study of the rock called ice. This rock, as it is found in glaciers, offers many interesting petrologic and metamorphic problems of interest not only to glaciologists but also to students of other rocks. Thanks to aid from The Geological Society of America, the National Research Council, and Yale University, the author has been able to develop techniques for thin-section studies of ice that are useful both in the field and in the laboratory. These techniques are described and their uses pointed out with the hope that glaciologists of the future will utilize them.

Because of the large grain sizes found in some glacier ice—occasionally 2 to 6 inches across—ordinary small thin sections are entirely unsuitable. Sections about 6 inches in diameter are most convenient. These can be made in the field, even at temperatures above freezing, and examined without magnification between sheets of polaroid. Fortunately the large grain sizes make magnification unnecessary, though a 10-power hand lens can be used to advantage. By means of a light-weight portable apparatus the sections can be so mounted as to allow photographs to be made easily. At summer temperatures prevailing on the surfaces of glaciers, sections will last from 15 to 30 minutes or more before completely melting—a length of time sufficient for worthwhile examination and photography. The time required to make a thin section is only 30 to 45 minutes. (Geological Society project.)

GLACIAL FEATURES NEAR CANAAN, NEW HAMPSHIRE

BY CHARLES S. DENNY

Studies, now in progress near Canaan, New Hampshire, indicate the following problems. The distinction, made originally by Upham, between a loose, grayish-white, bouldery and sandy "upper" till and a compact, grayish-brown, silty "lower" till is supported. The two tills are found on both granitic and schistose rocks. The "lower" till has a good cleavage. Small patches of limonite are found on these surfaces and elsewhere throughout the "lower" till to a depth of at least 10 feet. Only in a few places is the "upper" till slightly iron-stained to a depth of more than 3 feet. It is uncertain whether the "lower" till is subglacial debris and the "upper" till englacial debris (Upham's view) or whether the tills were deposited by two distinct Wisconsin ice advances, a hypothesis favored by the difference in depth of weathering.

Boulder garlands on the west slope of Mount Cardigan indicate ancient solifluction, probably periglacial. Such a process may explain the sharp upper limit of the stratified drift.

Kames and kame terraces were deposited by streams in pools adjacent to ice. The width of the zone, north and south, in which kames were deposited at any one time is unknown.

Podsol profiles show a dark layer rich in organic matter at the base of the leached zone. These profiles suggest a recent climatic change. (Geological Society project.)

GEOLOGY OF THE MEMPHREMAGOG QUADRANGLE, VERMONT

BY CHARLES G. DOLL

The Memphremagog quadrangle touching upon the International Boundary in northeastern Vermont is in large part underlain by relatively thin-bedded, metamorphosed sedimentary rocks of probable Ordovician age. These rocks compose the Memphremagog formation and consist chiefly of slates, phyllites, impure limestones, and quartzites.

The formation shows evidence of an Ordovician shore facies of a retreating sea, in the diminishing of the calcareous and a general progressive increase and coarsening of the argillaceous and siliceous beds to the southeast. Five facies have been moderately well determined, each defined by the predominant rock type present. The shallowness of the sea is seen not only in the rapid textural changes but is manifest also in such structures as ripple marks, cross-bedding, and sun cracks.

The strata have been squeezed into isoclinal folds trending northeasterly. They appear to be parts of a northerly-plunging major anticline covering the western two-thirds of the quadrangle. Cleavage and schistosity are everywhere practically parallel to the bedding, along which huge quartz veins and granite sills have been developed. Only minor faulting—small thrusts and transverse faults along strongly developed northwest fractures—has been observed. Plastic flow is a characteristic of the limestones.

The oldest rocks are granite gneisses intruded by post-Ordovician metabasics. The youngest rocks are granite stocks with accompanying dikes and sills of Devonian or later age. Metamorphism is middle-grade in the sediments, except in aureoles around the intrusives where it is high-grade.

CONSERVATION ADVANTAGES OF A GRASSLAND ECONOMY FOR NEW ENGLAND

BY W. ELMER EKBLAW

New England's agriculture at the time of its most important role in New England economy was based upon a system of land utilization of which grassland in the form of pastures and meadows was a major part. At that time New England's farm industry was most productive and relatively most profitable. At present pasture economy still remains significant in the farm industry, but, as cropland and farms have been progressively abandoned for a number of decades, reforestation has restored to wilderness hundreds of thousands of acres originally cleared at vast cost.

Return of much of this abandoned land to strictly pastoral uses—grazing of cattle, sheep, and goats—even if through State pastures, town pastures, and other forms of public-owned and publicly-managed meadows and pastures instead of to indifferent forest, would not only have produced greater aggregate income and more employment over a period of years but would also have been of appreciable conservation advantage.

Grass holds back run-off and retards or prevents erosion, in many places and under many conditions, as effectively as woodland. It tends to renew fertility both directly by its own action and indirectly through animal manures. It provides areas for wild fowl and other game; mixed grassland and forest sustain a much larger wild-life population than does uninterrupted forest. Interspersed with forest, grassland helps to prevent and control fire, pests, and tree diseases. It provides

open vistas of landscape, revealing views that continuous forest would conceal and, by creating a more gracious and hospitable countryside, contributes to the tourist and recreation attractiveness of the region.

The restoration of a grassland basis for New England's farm economy to a much greater extent than at present is both desirable and practicable. Reforestation need not be abandoned, but the encouragement of a pasture economy should be undertaken on the same scale and by the same methods as have promoted forest regrowth.

GEOGRAPHIC REGIONS OF NEW YORK STATE

BY ERIC H. FAIGLE

The National Research Council's Subcommittee on New York State Surveys is engaged in a research program which includes the geomorphic, climatic, natural vegetation, soils, agriculture, population, industrial, and urban regions of the State.

The preliminary draft of the geomorphic map has been completed. Under the supervision of Dr. George B. Cressey, New York State has been classified into 9 major and 25 minor regions. Previous boundaries in New York State have been strictly on a geological or physiographic basis. It was thought necessary to redefine these boundaries and in some instances to introduce new terminology.

The Committee has placed the development of a climatic map of the State under the direction of Dr. M. Catherine Roberts of State Normal School, Potsdam, New York. All stations of the State have been defined according to the Koppen classification, and a map of the State has been drawn showing the detailed Koppen regions. Later will be included critical, climatic factors which affect the distributions of crops, vegetation, growing season, and the like. The resulting map will present the 10 Koppen divisions of the State, together with new empirical topographic scale subdivisions of the basic chorographic scale zones.

Dr. Katheryne Thomas Whittemore of the State Teachers College at Buffalo is developing an extensive analysis of the agricultural regions of New York State. The population study is under the direction of Dr. Robert Simpson of the University of Rochester. At present he is working on distributions in the Finger Lakes Hills section. Soils, natural vegetation, urban, and industrial projects are under the direction of Dr. Joseph Russell of Syracuse University. He has nearly completed a map on the distribution of industries throughout the State.

STRUCTURE AND METAMORPHISM IN LEWISTON, MAINE, REGION

BY LLOYD W. FISHER

The geologic column in the Lewiston area of southwestern Maine, formerly mapped as pre-Cambrian, is as follows: the Cambrian (?) Pejepscot quartz-feldspar-biotite gneiss and schist; the Taylor Brook gneiss; the Cambro-Ordovician (?) lime-silicate gneiss, biotite schist, marble, and amphibolite; and the Silurian quartz-mica-sillimanite schist. All were originally sedimentary.

The Silurian Sabattus schist in the high-grade zone of metamorphism can be traced northeastward in a plunging anticline through the middle-grade zone Winthrop phyllite into the low-grade zone Waterville slates whose age has been determined by mid-Silurian graptolites.

Large igneous masses, including granite, granodiorite, gabbro, syenite, and pegmatite, and their associated dikes are regarded as late Paleozoic. Basaltic dikes of Triassic age cut some of the metamorphosed sediments. (Geological Society project.)

WISCONSIN GLACIATION OF THE PRESIDENTIAL RANGE, NEW HAMPSHIRE

BY RICHARD P. GOLDTHWAIT

The Presidential Range was entirely covered by an ice sheet in Wisconsin time, probably during a middle or late Wisconsin substage. This conclusion, implied by earlier authors, is reinforced by recently exposed pockets of fresh till on Mt. Washington, by erratic boulders with negligible stained rims on all peaks, by well-preserved striae on quartz veins and recently exposed schist ledges, and by one striated cobble on Mt. Adams. The last glaciation of the lower slopes was in the same glacial substage, for there is no morainic or other dividing line between upper and lower levels, the drift mantle on lower slopes is essentially fresh till, postglacial erosion has produced only youthful V-cuts in this till, and valley gravel deposits show steep ice-contact forms.

Large and small glacial erratics of several types were lifted 2000 to 4000 feet above sources now known in valleys to the northwest, showing that some of the ice traveled upslope over the highest places. Above the 5000-foot altitude on each peak erratic boulders are restricted to north and west slopes. This suggests that the load was smeared onto the slope from dragging lower layers of ice rather than dropped vertically onto each peak from wasting ice. Glacial scratches and oriented roches moutonnées show a uniform direction of motion S.40°E. on the peaks and high ridges, but clear markings and cliffs on the lowest knobs and slopes show local divergence of the last recorded ice motion by 50° into the east-west and north-south valleys.

GLACIAL FEATURES NEAR BENNINGTON, VERMONT

BY CLARENCE E. GORDON

Modified drift deposits are extensively developed in the Vermont Valley lowland north and south of Bennington. In topographic form, composition, structure, and distribution all the various deposits suggest that they have been developed in association with wasting, shrinking masses of stagnant ice which rested on an irregular bedrock surface. Terraces and other features built at different elevations, either along the margins of the lowland or on and against the rocky hills and ridges within it, indicate downwasting of the ice to lower and lower levels and lateral shrinkage from the valley walls and the slopes of the ridges.

Kames, ridges, and ice-contact terraces or plains are found at different levels. Kame topography of the hummocky, "knob and basin" type and broad plains with well-developed contact slopes are more common in the latest stages of the waning ice. Single, large, more or less isolated kames or ridges are sometimes conspicuous features of the higher terrace levels, rising above the general surface on which they stand.

During the process of wastage and shrinkage the ice was at all times characterized by more or less irregular margins and in greater or less degree by rifting or crevassing and by fragmentation of its mass into irregular blocks. In the spaces within the shrinking ice the meltwaters left their loads.

Throughout the region numerous areas at different levels, ill-drained and swampy, frequently detached but often forming parts of the present drainage system, mark the last stands of wasting ice masses.

GREEN MOUNTAINS OF NORTHERN VERMONT

BY ELBRIDGE C. JACOBS

The major structure of northwestern Vermont, between Montpelier and Lake Champlain, is thrust faulting, with older formations thrust upon younger ones along two major and many minor faults. In Essex Junction the mountain metamorphics are in contact with Lower Cambrian graywackes and are judged to be of this age.

The Green Mountains, in the latitude of Burlington, are made up of two ranges: the Main Range, which includes the highest peaks, and the Worcester Range. Stowe Valley lies between them. Mountains and valleys are made up wholly of metamorphic rocks and intrusives.

The Main Range is an open anticlinorium, of low dips, somewhat overturned to the west. The dome of the largest anticline has been eroded by fluviatile and glacial action forming synclinal Mount Mansfield, anticlinal Smugglers Notch, and the synclinal Sterling Range. The rocks are schists, gneisses, and underlying quartzites and belong to the chlorite, biotite, and garnet zones of metamorphism. They are much contorted and show drag folds.

Unconformably against the eastern flank of the Main Range is the steeply dipping, isoclinal Missisquoi formation (Cambrian) of Stowe Valley and the western flank of the Worcester Range. This range, as a whole, is an open synclinorium.

In the adjoining Worcester Valley, to the east, the Missisquoi formation is in nonconformable contact with phyllites, probably Ordovician.

The mountains have been heavily glaciated, but the till has been largely removed below approximately the 2700-foot contour.

ECONOMICS AND NEW ENGLAND MINERALS

BY RAYMOND B. LADOO

Important as geological, mineralogical, and technological studies are, the essential considerations in the development of New England's minerals relate to the broader economy of new industrial markets and their demands. What minerals new industries need, where they can be found, how the development of deposits can be financed, what legislative controls can be tolerated and what should be needed, how large an operation is required to be profitable, whether a more expensive New England process will balance against transportation costs—all these are problems to be considered. In order of relative importance the various factors to be studied are: (1) capital; Venture capital must be available; (2) markets; statistical study of consumers is not enough; technological demands of potential consumers must be known; (3) technical developments; it is necessary to go behind the mineral product specifications to find how mineral products can better be mined, milled, treated, and blended so as to increase marketability. Last, co-ordination of old mineral and geologic surveys, supplemented by new ones, is essential.

ASSOCIATION OF FOSSILIFEROUS CLAYS AND GRAVELS UPON ESKERS

BY RICHARD J. LOUGEE

The literature on the glacial geology of New England includes descriptions of "fossiliferous eskers" in marine areas and implies the presence of living marine forms in glacial melt water. This implication, if true, is a biological paradox. An inspection

of the references and personal acquaintance with several such localities leads the writer to agree with the view of Gerard DeGeer that fossiliferous deposits are not original parts of an esker but may be reworked gravels, sands, and clays deposited upon or around the eskers during late stages of the marine period. Sections reveal unconformable contacts between fossiliferous materials and the barren esker gravels, and the fossils commonly occur in dipping beds which resemble aprons of wave- and current-built sediment washed from higher parts of the esker. The eskers may occur 100-200 feet or more below the summit level of the marine water in which they were formed, as proven by associated glacial deltas, and yet these deep-water eskers may have upon them such shallow-water types as barnacles. This implies that the fossils lived on the esker at a time when the waters were shallowed to levels well below the marine limit and when wave action modified the emerging ridges.

If the true nature of the fossiliferous sediments is recognized it becomes apparent that wave and current action account for numerous deposits hitherto classified as "glacial".

RETREATAL STAGES OF WISCONSIN ICE IN SOUTHEASTERN MASSACHUSETTS*

BY KIRTLEY F. MATHER, LINCOLN R. THIESMEYER, AND RICHARD P. GOLDTHWAIT

Recently completed topographic maps with scale of 2 inches to the mile and contour interval of 10 feet have been used as bases for detailed mapping of Quaternary formations in nine 7½ minute quadrangles extending from Plymouth southward to Woods Hole, as part of a co-operative project for geological investigations in Massachusetts. Results of the 1939 field season have been previously presented; work done in 1940 provides the principal data for this paper.

As the margin of the Wisconsin ice withdrew northward from the terminal moraine appearing above sea level on Marthas Vineyard and Nantucket, it became more lobate, and a series of recessional moraines and abundantly pitted outwash plains was constructed. Some of the moraines indicate appreciable readvance; others merely a temporary halt. In places, the position of the ice front is marked by extensive kame fields.

The margin of the Buzzards Bay lobe withdrew northwestward, whereas the Cape Cod Bay lobe withdrew northward. Withdrawal was not uniform; the Kings Pond pitted plain, for example, was built between the Buzzards Bay ice and the Hog Rock moraine, from which it had just withdrawn, by melt water from the Cape Cod Bay lobe, while the Plymouth kame field was being formed. Directions of ice movement are indicated by transported material, trends of recessional moraines, and glacial striae at Rocky Nook in Kingston, the most southeasterly outcrop of bedrock along the shore of Massachusetts Bay. Ice of the Cape Cod Bay lobe was moving S. 25° W. when those striae were formed.

SHORELINE CHANGES ON PLUM ISLAND, MASSACHUSETTS†

BY ROBERT L. NICHOLS

Plum Island is a barrier beach between 7 and 8 miles long and in most places between ½ and 1 mile wide. Its northern end is forked. The eastern prong, on

* Presented with the permission of the Director of the United States Geological Survey and the Commissioner of Public Works, Commonwealth of Massachusetts.

† Published with the permission of the Director, Geological Survey, U. S. Department of the Interior.

which there are more than 100 cottages, is approximately 1¼ miles long and at its widest point ½ mile wide. The western prong is approximately 3500 feet long and as much as 1400 feet wide. Between the two prongs is a shallow body of water, called the Basin, which is about 1 mile long and approximately 1000 feet wide.

A study of maps made by the U. S. Army Engineers shows that the eastern prong has been formed in the last 113 years.

In 1827 the northern end of Plum Island was not forked. Between 1827 and 1851 the eastern side retrograded about ½ mile southward. That part of the western side which remained was later modified to form the western prong. Following this period of southward retrograding a spit, attached to the eastern side, prograded itself northward so that by 1851 it was more than a mile long. Between this spit and the western prong the Basin was formed. Since 1851 this spit, the eastern prong, has greatly increased in size, so that today it has an area of approximately .3 square mile.

The formation of these features is due to the longshore currents and to the currents in the Merrimack River, which reaches the ocean just north of Plum Island.

An analysis of still older maps reveals that several cycles of prongs and basins have been formed and destroyed on the north end of Plum Island.

MAGMATIC CONTRASTS IN THE LAKE WINNIPESAUKEE AREA OF NEW HAMPSHIRE

BY ALONZO QUINN

The Lake Winnipesaukee area of central New Hampshire has been the site of two episodes of igneous activity of strikingly different characteristics. The New Hampshire magma series is of probable late Devonian age, and the White Mountain magma series is of possible Carboniferous age.

The following are some of the chief characteristics of the New Hampshire magma series: the plutonic origin of all the rocks; the large partially concordant intrusions; intrusion under weak pressure in the late stages of orogeny; much pegmatite of simple mineralogy; a normal content of alkalies; the presence of quartz and muscovite in most of the rocks; restriction of the rocks mainly to quartz diorite, granodiorite, quartz monzonite, and granite; the apparent lack of system in the variations and order of intrusions; and the scarcity of dikes, except aplite and pegmatite.

In marked contrast are the characteristics of the White Mountain magma series: the presence of both extrusions and intrusions; the small crosscutting ring-dikes and stocks; cauldron subsidence as a common method of intrusion; the scarcity of pegmatite; the high content of alkalies, especially soda; the presence of syenites and feldspathoid syenites; the presence of pyroxene, amphibole, olivine, fayalite, hastingsite, riebeckite, nepheline, and sodalite; the great range of rocks from gabbro through diorite, monzonite, syenite, feldspathoid syenite, quartz syenite, and granite; the systematic variation of intrusions from gabbro to granite; and the abundance of dikes of many types.

MINERAL RESOURCES OF NEW ENGLAND

BY HAROLD LADD SMITH

The paper presents a brief review of the New England Council and its objectives as a background for the New Products Committee of which Dr. Karl T. Compton is chairman. One project undertaken by this committee has been reappraisal of the mineral wealth of the area. For this purpose a special committee on mineral resources was appointed. The potential value of New England's minerals resides

largely in oxide and nonmetallic minerals. Recently developed industrial uses for these nonmetallics together with improved methods of ore treatment throw into sharper relief the disseminated occurrences typical of the region. Although the investigation is incomplete, interim reports indicate that the committee's judgment in undertaking such a program was well founded.

In order to define the scope of the problem and to assure more rapid progress, 13 subcommittees were organized. A summary of the work of each is presented. The need for correlating available data, of which there is a vast amount, is apparent. Studies by such an all-New England committee emphasize the importance of treating the area as a unit if commercial exploitation of its resources is projected.

Finally there is sketched the necessity of a permanent organization to implement the findings of the committee and thus bring one step nearer to actual development those mineral deposits warranting exploitation. The relative stability of industrial operations based on the utilization of a natural resource is stressed.

MT. WALDO, MAINE, PLUTON AND ASSOCIATED IGNEOUS ROCKS

BY JOSEPH M. TREFETHEN

The central part of the Bucksport, Maine, topographic map area is underlain by a medium-textured, porphyritic, biotite granite, termed here the Waldo granite. The age of the granite has not been determined but is probably either Devonian or Carboniferous. The pluton is roughly circular in plan, with a diameter of approximately 10 miles. Plane flow structures in the granite tending to curve parallel to the margins of the intrusion about the northern end stand steep to vertical. Within the intrusion, the plane flow structure averages about north in strike and vertical in dip. Linear structure is not developed. On the north, northeast, and south, the older metamorphic wall rocks, probably Paleozoic, are cross-cut by the Waldo granite; elsewhere, the structure of the wall rocks tends to conform to the outlines of the intrusion. Close to the intrusion, the axes of the minor folds in the wall rocks are steeply inclined or vertical; farther from the margins, the pitch of such minor folds decreases. The overlying rocks were perhaps pushed bodily upward by the intrusion.

Intrusives older than the Waldo granite are granitic and more basic. Both groups are of undetermined age. The earlier granites, termed Winterport type, are foliated and locally show linear structure consisting of biotite streaking on the foliation planes. This type outcrops in small masses. Pegmatite and aplite dikes are present, some older and others younger than the Waldo granite. Diabase dikes are the latest intrusions in the area.

DISTRIBUTION AND STRATIGRAPHY OF THE LOESS

BY EARL T. APFEL

Loess occurs as a discontinuous mantle over the central plains and in the Columbia plateau area, while scattered loess patches are found in Connecticut, Massachusetts, New York, and elsewhere. The distribution is shown on maps.

The stratigraphic loess unit is ideally that loess and associated material deposited during a single depositional cycle such as occurred during an interglacial interval. In the areas of superimposed drifts in Illinois, Iowa, and Nebraska such units have been recognized and usually named according to the interglacial interval in which they were formed.

Beyond the limits of superimposed drifts the loesses merge. A pre-Peorian erosion interval, a soil zone on the older loess, and somewhat different sources of material make Peorian loess distinguishable from that which preceded it. The name Loveland designates the pre-Peorian loess which is widespread from eastern Iowa to western Nebraska. Both Loveland and Peorian loesses are complex in origin and probably include deposits of more than one episode. Loess which is distant from the drift margin has not in many cases been correlated with any of those named.

Future work should yield more precise correlation of the loess outside the drift borders with the loess which is precisely dated by its drift association and thus enable areal mapping of the loess of each age. Sources and climatic factors might be inferred from such maps.

ROLE OF FUNDAMENTAL GEOLOGIC PRINCIPLES IN THE OPENING OF THE ILLINOIS BASIN

BY ALFRED H. BELL

The Illinois basin is here defined as the central deepest portion of the Eastern Interior basin. It includes approximately 8000 square miles between the Centralia-DuQuoin monocline on the west and the La Salle anticline on the east (70 miles) and approximately from the latitude of Mattoon on the north to that of Shawneetown on the south (125 miles).

Important production of oil had been obtained in the marginal areas both to the east and west beginning in 1905, but it was not until 1937 that oil was produced in the Illinois basin. Subsequent development brought Illinois back from an insignificant position to its previous rank of third in the nation in oil production. In regaining this rank it was necessary to produce oil at 4½ times the previous peak rate.

The delay in opening the Illinois basin was the result of several factors, the most important of which was perhaps the widely held theory that oil had migrated out of the central parts of major structural basins and had accumulated in structural traps in the marginal areas. Consequently, the central parts of the basins were held to be barren of oil and not worthy of prospecting. This theory was refuted in a spectacular manner in 1928 when a major oil field was discovered near Mt. Pleasant, Michigan, in the very center of the Michigan basin.

This paper discusses (1) the sequence of events leading up to the discovery of oil in the Illinois basin, with special emphasis on the influence of geologic theory, (2) the application in the area of the new techniques of exploration and development including geophysical methods, rotary drilling, and electric logging. The use of the reflection seismograph method proved highly successful.

GLACIAL EVOLUTION OF MICHIGAN

BY S. G. BERGQUIST

The Labradorean ice sheet which invaded the Great Lakes region in the Wisconsin stage of glaciation found its way into a network of preglacial troughs which undoubtedly had been employed as thoroughfares for ice flow during the preceding Illinoian invasion. The Michigan, Erie, and Huron lobes, deeply keeled in their respective troughs, were definitely directed in primary movement by the courses of the valleys which they occupied. They expanded landward and overflowed their basin rims only during intervals of excessive nourishment.

The Saginaw lobe, on the other hand, was not restricted in its movement by confining walls of rock but was free to spread out as a thin sheet over the surface of the upland interior. The extent of its deployment was determined largely by the volume of ice fed into it by the Huron glacier which nourished it. Because of the limited thickness of the ice and the character of the surface over which it moved, the Saginaw sheet responded more quickly to changing conditions of climate than did the more massive lobes that were keeled in the basins. In its vicissitudes of advance and retreat it exerted a marked influence on the marginal extension into Michigan of the other lobes.

A series of morainal ridges arranged more or less parallel to the ice margin mark the succession of back steps and consequent short halts of the ice as it retreated by melting. In addition to these minor adjustments as determined by climatic fluctuations the ice that covered Michigan made two major recessions which were followed by marked readvances before the Wisconsin stage came to a close. The first of these recessions took place shortly after the completion of the Sturgis moraine. At that time the ice melted back to a position considerably north of the Kalamazoo morainic system, and it is possible, as inferred by Leverett, that more than half the State was uncovered before the ice sheet readvanced to form the Tekonsha moraine. The second important recession occurred during the Arkona stage of lake history when the ice sheet retreated at least to the region of the Straits to lay bare the entire Southern Peninsula of Michigan. This recession was followed by a readvance of the ice to the position of the main outer ridge of the Port Huron morainic system during the stage of Lake Whittlesey.

MODERN CONCEPTS OF THE PHYSICAL CONSTITUTION OF COALS*

BY GILBERT H. CADY

Studies of the physical constitution of coals are concerned with the nature of their physical heterogeneity. Subdivision of coals into banded and nonbanded varieties is basically petrographic as it depends upon the presence or absence of vitrain. Another petrographic generalization differentiates vitrain, clarain, durain, and fusain. These are primary varieties or types of coal. Type classification of coals involves an understanding of the physical and chemical properties of these primary types of coal and the manner of their association to produce coals of different kinds.

Coal contains plant fragments (phyterals), their substance composing the macerals. The relationship is suggestive of that of crystals and minerals. Type classification of coals is determined by the character of the maceral or macerals of which they are composed and by the proportion and manner of occurrence of the primary coal varieties (ingredients). By reference to such considerations coals can be accurately

* Presented with permission of the Chief, Illinois State Geological Survey.

described in the field and laboratory and be synthesized to conform to petrographic specifications.

Coal petrography has significance in the preparation, processing, and utilization of coals.

A by-product of this study is the possible use of the fossil plants (phyterals) in stratigraphic paleobotany and in the interpretation of the natural history of coal beds.

The permanent value of studies of the physical constitution of coals depends very largely upon demonstration of the chemical individuality of the physical entities and of the primary coal types (ingredients).

CONTRIBUTIONS OF BOTANICAL SCIENCE TO THE KNOWLEDGE OF POSTGLACIAL CLIMATES

BY WILLIAM S. COOPER

Botanical science contributes to the knowledge of postglacial climates in two general ways: through inference from plant remains of various sorts, and from the distribution of existing vegetation.

Under the first, fossil pollen grains, especially of forest trees, from various levels of peat deposits are the most useful indicators. In the glaciated portion of eastern North America the lowest beds show universal dominance of fir and spruce. Above the lowest there is regional differentiation. The southernmost deposits show replacement of spruce-fir by pine-oak, with some increase of other hardwoods. Farther north spruce-fir is succeeded by pine-oak, but spruce reappears in the uppermost layers. Still farther north, in the region of present conifer dominance, spruce-fir declines toward the middle and increases again toward the top. The most reasonable inference from these facts seems to be that the postglacial climatic sequence in eastern America was from glacial through cool-moist to warm-dry conditions culminating in mid-post-Pleistocene time, with a return to a cooler, moister climate during the last few thousand years.

The distribution of existing plant communities provides a basis for reasonable inference as to past vegetational history and therefore past climatic changes. Isolated colonies of a particular type embedded in extensive masses of a totally different type are definite evidence of past changes. In our glaciated region, colonies of conifers far south are relics from early postglacial conifer dominance conditioned by subarctic climate. Colonies of certain hardwoods far north seem to be relics persisting from the mid-post-Pleistocene warm-dry period when hardwood dominance extended farther north than now.

The pollen record and the facts of plant geography thus apparently agree in indicating a mid-post-Pleistocene warm-dry period followed by a return toward cool-moist conditions. There is further agreement, moreover, with conclusions drawn from nonbotanical evidence along several lines: glacial history in Alaska, history of saline lakes in the Great Basin, disappearance and reappearance of small glaciers in the Sierras and Rockies, formation of continental sand dunes, and the trend of the geothermal gradient.

MICROPALEONTOLOGY IN PETROLEUM EXPLORATION

BY CAREY CRONEIS

This paper surveys the new frontiers in micropaleontology with especial emphasis on those groups of microfossils which have not yet received the attention their presumed potentialities suggest they merit. In this category belong protozoans

other than Foraminifera, microscopic plant remains, such as silicoflagellates, coccoliths, discoasterids, and spores and pollen, as well as fragments, dissociated parts, or growth stages of typically megascopic fossils, such as crinoids, holothurians, bryozoans, worms, trilobites, and so forth.

New methods of collection, separation, and study of microfossils are considered, including the problems of the examination for microscopic remains of dredgings and of oil field liquids. Potential uses for microfossils in the search for petroleum are discussed, and the thesis is advanced that in the future micropaleontologic studies will be able to contribute not alone to the routine identification of horizons penetrated by the drill, as at present, but to the solution of some of the more obscure, yet vitally important, geological problems concerning oil and gas, such as the evaluation of the roles of the organic, paleogeographical, sedimentological, stratigraphical, and structural factors in the origin and localization of these hydrocarbons.

PHYSICAL CONSTITUTION OF COAL AS RELATED TO COAL DESCRIPTION AND CLASSIFICATION

BY E. C. DAPPLES

Present-day classification of coals indicates a marked boundary between banded and nonbanded varieties. In banded coals the principal physical constituents—vitrain, clarain, durain, and fusain—are visibly distinct. Nonbanded coals need not be considered a separate group since cannel is gradational into durain, and durain grades into "bone-coal" of high mineral matter content. Despite their megascopic appearance as separate entities the units of banded coals are closely interrelated, as in thin sections they may be seen to merge. Such constituents increase in rank with progressive metamorphism. Accompanying the rise in rank is a corresponding change in the physical appearance. Some constituents such as cannel and durain tend to resist physical change, whereas fusain, clarain, vitrain, and resinous bodies (in order of their increasing sensitivity) alter their physical properties with increase in rank. In black lignites distinction between clarain and vitrain is difficult, but with increase in rank each assumes unique characteristics. The greatest divergence in properties between the two is reached in high volatile bituminous coals, whereas in higher ranks the distinction between clarain and vitrain becomes increasingly more difficult. Fusain is rather resistant to progressive metamorphism and is most readily recognized in bituminous coals. In anthracites its luster is altered to approach that of vitrain. Increase in width of the individual bands has a considerable effect upon the fracture of the coal, and a decrease in thickness of bands produces a finely laminated coal whose properties combine those of clarain and vitrain. Resinous bodies whose nature is not at present well understood have optical properties which vary with progressive metamorphism and may prove of value in classifying subbituminous and lignitic coals.

GLACIER FLOW AND ITS BEARING ON THE CLASSIFICATION OF GLACIERS

BY MAX DEMOREST

The mechanisms of ice flow under various conditions are analyzed for the purpose of presenting a fundamental concept of the differences that exist among glaciers. It is shown that there are four types of movement, here called (1) extrusion flow, (2) obstructed extrusion flow, (3) obstructed gravity flow, and (4) gravity flow. The four types form a gradational series that cannot be sharply separated, yet each is

characteristic of distinct glacial conditions. The first two are grouped together as pressure-controlled types of flow because they result from differential pressures. They are characteristic of glaciers lying on nearly horizontal floors and having surfaces of very slight slope (ice sheets, ice caps, piedmonts, and some valley glaciers). The second two are grouped together as drainage-controlled types of flow because they occur only where glaciers lie on floors of sufficient slope to cause relatively rapid drainage from higher-level sources of supply (outlet glaciers from ice sheets and many valley glaciers). Shear components of direct gravitative forces are principally responsible for movement.

In tabular form these types of flow and their controls are as follows:

Pressure controlled (dependent on slope of glacier surface)	EXTRUSION FLOW	Shear stresses due to differential pressure and differential plasticity
	OBSTRUCTED EXTRUSION FLOW	
Drainage controlled (dependent on slope of glacier floor)	OBSTRUCTED GRAVITY FLOW	Shear stresses due to components of gravity
	GRAVITY FLOW	

PROGRESS AND PROBLEMS IN THE NORTH AMERICAN PLEISTOCENE

BY RICHARD FOSTER FLINT

The basic information on North American glaciation that has been gained during the past 50 years is briefly reviewed. In recent years special progress has been made in correlating glacial events with fluctuations of sea level, in our understanding of crustal warping by glacial loading and unloading, and in improving our time table of the later Pleistocene by means of organic, chiefly botanical, evidence.

One of the important tasks that face us now is to explain the location and mode of origin of the great Pleistocene ice sheets in the Northern Hemisphere. It has long been held that these ice caps grew *in situ*, but that hypothesis encounters meteorologic objections that are apparently insuperable. Instead, it is suggested that the ice caps were immigrant or intrusive into the regions with which they are identified.

In harmony with evidence that the Scandinavian ice sheet originated as Alpine glaciers on the Swedish-Norwegian divide, it is suggested that the Labrador and Keewatin ice sheets originated as Alpine glaciers in the mountains of Labrador and Baffin Island, respectively, and that, fed by westerly cyclonic storms, they coalesced to form piedmont glaciers and, later, ice sheets that buried the mountains themselves.

Rapid further progress in Pleistocene stratigraphy will depend more than ever on planned, co-ordinated effort by groups that include scientific workers other than geologists. Such planning should be put into effect at once.

ILLINOIAN-IOWAN DRIFT COMPLEX OF DAKOTA COUNTY, MINNESOTA

BY L. M. GOULD

The thin Iowan drift sheet which is stratigraphically located between the Illinoian and the Wisconsin has been considered by various investigators as late Illinoian, an independent sheet, and early Wisconsin. Perhaps the most critical area for the determination of the relationship of the Iowan to the Illinoian is to be found in Dakota County, Minnesota. Here the "old red drift" described as Illinoian by Leverett and the Iowan are in contact.

Detailed mapping shows that in places the young gray Iowan is mixed with the old red in a confused mass. In other places it is absent, as in parts of the Hampton moraine of Illinoian age. It appears that hills of this moraine may have either projected above the thin Iowan ice sheet as nunataks or have been high enough so that the overriding ice eroded rather than deposited. In still other places the gray Iowan drift forms a thin but definite veneer on top of the Illinoian. Stratigraphically the Iowan was clearly deposited after the "old red drift." If the latter is actually Illinoian then the Iowan should be regarded as early Wisconsin. Comparative tests for leaching indicate that the Iowan is related to the youngest Wisconsin here exposed—the Mankato drift which covers much of the western part of Dakota County.

MODERN CONCEPTS OF CLAY MATERIALS

BY RALPH E. GRIM

The paper reviews the old ideas of the composition of clay materials and the recent researches using modern research tools that have led to the present generally accepted concept of the clay-mineral composition of these materials. According to this concept, clay materials are composed essentially of minute crystalline particles of any one or more members of a few groups of minerals known as the clay minerals. Using this concept as a point of departure, researches starting from the many fields in which clay materials are important, from agriculture, engineering, geology, and the ceramic, rubber, paper, petroleum, and many other industries, have in the last 15 years made outstanding progress toward a more satisfactory and complete understanding of the precise composition of clay materials, their structure, and the factors that determine their properties.

The occurrence of the various clay minerals in soils, contemporaneous sediments, and ancient clays and shales is summarized briefly, and general conclusions are drawn that seem warranted in the present status of our knowledge. As a basis for other papers, pertinent information on the composition, structure, and certain properties of the individual clay minerals is assembled. Finally the structural relationships of clay-mineral particles and water are analyzed for clay materials in the plastic state, and some new interpretations are suggested.

RELATION OF THE LATTICE STRUCTURE OF CLAY MINERALS TO SOME PROPERTIES OF CLAYS

BY STERLING B. HENDRICKS

Minerals appearing in clays generally have layer lattice structures formed from: (1) uncharged layers with hydroxyl ions on both surfaces, (2) hydroxyl ions on one surface and oxygen ions on the other, (3) oxygen ions on both surfaces; (4) charged layers with oxygen ions on both surfaces, or (5) two types of layers one with hydroxyl ions on both surfaces and the other with oxygen ions on both surfaces. The discussion will be limited to: (class 1) kaolin minerals, serpentines, and cronstedtite; (class 3) pyrophyllite, and talc; (class 4) hydrous micas (illite, bravaisite, pholidolite, glauconite, celadonite) and the montmorillonite-nontronite group of minerals. Some new information on the montmorillonite-nontronite group, anauxite, and chrysotile will be summarized.

Factors limiting composition, base exchange, polymorphism, crystal size, and behavior toward water will be discussed.

APPLICATIONS OF MODERN CLAY RESEARCHES IN AGRICULTURE

BY W. P. KELLEY

The researches on the clays are of great importance in the chemistry, physics, and genesis of soils. Formerly inorganic soil colloids were thought to be composed largely of uncombined oxides and hydroxides of silicon, iron, and aluminum, and soil clay was looked upon as being amorphous. During recent years it has been shown that clay minerals are important constituents of soil colloids generally. The phenomena of base exchange, absorption in general, and the structure and tilth of soils are all greatly influenced by the clay minerals of soils. Investigations on these subjects have already been considerably influenced by the researches on the clays. The discovery that the clay minerals are widely distributed in soils, and that certain soils contain kaolinitic clay minerals, others contain montmorillonitic clay minerals, and still others contain micalike clay minerals, has stimulated interest in the question: What are the essential conditions for the formation of the different clay minerals? The researches on the clays have served to show the close relationship between soil science and geology.

PRINCIPLES OF SEDIMENTATION AND THE SEARCH FOR STRATIGRAPHIC TRAPS

BY W. C. KRUMBEIN

The need for a more thorough understanding of sedimentary principles has become increasingly apparent as geological exploration for petroleum moves toward the location of nonstructural traps. The present paper reviews some of the principles involved in the study of sedimentary environments and attempts to show that a study of fundamental properties of sediments may prove basic to future exploratory work.

The role of basic research is to explore new paths to knowledge through the evaluation of such fundamental sedimentary parameters as size, shape, roundness, composition, surface texture, and fabric. The relation of these parameters to mass properties such as porosity and permeability needs study, and a knowledge must be gained of conditions which control the lateral and vertical variations of these mass properties in sedimentary environments. From such fundamental studies, indices which are helpful in tracing porosity wedges and flank sands may be developed. In addition to studies of clastic sediments, conditions of formation of nonclastics must be attacked. The role of practical application lies with petroleum geologists, whose task includes the use of the newer principles in exploration and their further development or discard as exploration continues.

It is emphasized that sedimentary research is only one of several lines of attack on petroleum exploration by geological methods. The closer co-ordination of paleontologic, stratigraphic, and sedimentary work should insure a continuously expanding frontier in the geological search for oil.

MAJOR ASPECTS OF THE GLACIAL HISTORY OF ILLINOIS

BY M. M. LEIGHTON

The major drift sheets of Illinois are Labradorean in origin. The Keewatin field lay mainly to the west and affected only parts of western Illinois.

Illinois was also in the path of the moisture-laden winds from the Gulf of Mexico, and due to this and its low relief the most southern limit of continental glaciation lay within its borders.

The Driftless Area of northwestern Illinois was a part of a high inter-drainage area, connected with the pre-Cambrian area of central Wisconsin, which separated the Great Lakes drainage system from the Minnesota-Iowa drainage system, both of which were paths for the flow of the several ice flows.

Most of Illinois remained driftless during the Nebraskan and Aftonian stages, in contrast with Iowa and other States that lie in the Keewatin field. In fact, little is known about the Labradorean ice field during the Nebraskan stage. Illinois retained most of its stream-erosion topography and residual soils until the Kansan stage.

In the Kansan stage, the Labradorean ice covered most of Illinois, extending almost to the maximum limit of glaciation. It is not known whether this was exactly contemporaneous with the Keewatin lobe that covered such large areas west of the Mississippi River and radiated into a fringe of western Illinois.

In the Illinoian stage, Illinois received its most generous gift of new soil from the Labradorean ice field, which covered five-sixths of the State. Weathering and erosion persisted on the Kansan drift of most of the Keewatin area advancing the stage of development beyond that of the Kansan in Illinois.

The Labradorean ice, in the Wisconsin stage, reached Illinois after the Keewatin ice reached Iowa, and in the northeastern part of the State there were outstanding examples of moraine building of the smooth broad type. The actual glaciation of Illinois was finished considerably before the Des Moines Lobe in Iowa was formed.

These and other matters, including the loess deposits and their relation to the valley trains, will be summarized.

TRENDS IN PETROLEUM GEOLOGY

BY A. I. LEVORSEN

One of the peculiarities of the oil industry, and one in which it differs from many of the other industries using the minerals of the earth, is that its supplies of crude oil must be replenished continually by new discoveries. It is in the field of oil discovery that the petroleum geologist finds his chief work.

The use of the microscope, with the consequent increase in detailed and accurate stratigraphic data, has proved to be a most important tool of petroleum geology. Not only does it give a better understanding of underground stratigraphy but it also has stimulated an awareness of the importance of geologic history in the discovery process. The present trend is strongly in the direction of the application of these data to the problems of stratigraphy and sedimentation.

There is a growing trend of petroleum geologists into executive and managerial positions within the industry and into the oil business as independent operators. Probably as a result of this broadening viewpoint, a greater interest in the college curricula of geological colleges is developing. In many ways, the petroleum geologist is becoming an "oil man."

RELATION OF THE PHYSICAL CONSTITUTION OF COAL TO ITS CHEMICAL CHARACTERISTICS

BY H. H. LOWRY

The paper is mainly a review of published data on the chemical nature of the banded constituents of coal seams. Consideration is given to ultimate and proximate composition and to the nature of the products obtained by oxidation, reduction, and thermal decomposition. In general, the petrographic components of coals

from a given seam differ in chemical composition, but the differences are not quantitatively nor qualitatively constant when coals from various seams are prepared. The inconsistencies in results reported are attributed, in part, to difficulty in obtaining "pure" petrographic components and in expressing the petrographic composition quantitatively. Essentially distinct types of chemical compounds peculiar to the ingredients of banded coal have not been found.

CORRELATION OF GLACIAL AND MARINE FEATURES OF THE ATLANTIC COAST

BY PAUL MAC CLINTOCK

Pitted and overridden fossiliferous marine clays show that the sea transgressed the margins of Newfoundland while glacial ice was still active there. Pitted marine clays in Maine also show contemporaneous glacial ice and marine invasion of the present land area. The marine formations therefore should be considered as late glacial rather than as postglacial.

Sayles finds warm-water fauna picked up and deposited in till of eastern Cape Cod. Cushman finds warm-water Foraminifera at Sankaty Head, Nantucket. Fuller and others find warm-water fauna in the Gardiners clay of Long Island overlain by Ronkonkoma drift. This then is an interglacial deposit when the sea transgressed the present land.

The Cape May and Talbot formations of New Jersey and Maryland are to be correlated with the Gardiners clay. They likewise contain warm-water fauna. They are transected by the Delaware River Wisconsin valley train which is graded to a lowered sea level. Their surface topography shows marine constructional forms slightly modified by fluvial erosion. If Fisk's findings, in the lower Mississippi Valley, of five episodes of low sea level and four episodes of high sea level during the Pleistocene be applicable to the Atlantic seaboard, the Cape May and Talbot formations would be of Peorian age. Flint considers this most likely in Virginia and the Carolinas where he finds this and also a higher escarpment which is still fresh enough to be of Sangamon age. Such a correlation would make the Peorian a time of major deglaciation over the world.

Recently Richards has found a marine fauna 60 feet above sea level near Monks Corners, South Carolina, containing a mixture of Pliocene and Pleistocene fossils dating it as early Pleistocene.

MODERN CONCEPTS OF THE PHYSICAL CONSTITUTION OF COAL AND RELATED RESEARCH IN GREAT BRITAIN

BY C. E. MARSHALL

In recent years there have been resolved many differences of opinion which formerly existed between the so-called British and American "schools" of coal petrology. This is largely due to the now general realization that there are no essential differences between the normal coal types and constituents of the Carboniferous seams of the two countries.

Controversy within the British "school" has been reduced by Stopes' revision of her original petrological classification and the adjustments suggested by the Heerlen Conference.

The majority of the discrete, brilliant bands (vitrain of Stopes, anthraxylon of Thiessen) which form a considerable part of most coal seams have been derived from fragments of cellular tissue. Most commonly preserved in this way are bark

tissues of *Bothrodendron, Lepidodendron,* and *Sigillaria* as well as wood tissues of gymnosperms and Cycadophytes.

Isolation of the various coal constituents and their examination chemically and petrologically is vital to the investigation of rank and type variation. In this connection, vitrain has afforded a convenient and valuable source of "pure" coal, and interesting results have been obtained from its examination.

The importance of petrographic analysis to the economic and efficient utilization of coal is becoming increasingly apparent. Interim reports of the method of "proximate and ultimate petrological analysis" devised by Dr. C. A. Syler, in which resolution of the coal constituents is effected by measuring their reflectivity with the Berek photometer, promise interesting developments.

Petrological investigation of the mineral matter of coal seams is also becoming increasingly important. Detailed microscopic examination of the mineral matter of the seam has frequently solved problems of utilization and treatment which did not yield to any other method of investigation.

REBIRTH OF THE GLACIERS OF THE SIERRA NEVADA DURING LATE POST-PLEISTOCENE TIME

BY FRANÇOIS E. MATTHES

The small cirque glaciers of the Sierra Nevada are commonly believed to be shrunken remnants of the large glaciers of the Pleistocene epoch. However, the massive and fresh-looking moraines at their fronts, in several typical instances, at least, consist of "dead" glacier ice thinly mantled with morainal material. The total bulk of fresh morainal material deposited by these glaciers therefore is not large and can hardly represent an accumulation of 10,000 years. The wasting away of some of the smaller glaciers, moreover, reveals that they lie in part on Post-Pleistocene talus. These facts indicate that these glaciers have been in existence but a short time and are successors to, rather than remnants of, the Pleistocene glaciers. They probably originated at about the same time as Owens Lake, which is fed very largely by the snows of the Sierra Nevada. From its salt content an age of less than 4000 years has been calculated. The lake and the glaciers therefore may have been reborn with the advent of the present relatively cool and moist conditions after the climatic optimum of the Post-Pleistocene had passed. Assuming synchronism between the later climatic oscillations in Europe and in the western United States, it seems probable that the Sierra glaciers made their culminating advances, as did the European glaciers, in the seventeenth, eighteenth, and nineteenth centuries, and that their moraines with ice cores date from the last great maximum which in Europe was recorded in 1850-1855.

PRACTICAL SIGNIFICANCE OF THE PHYSICAL CONSTITUTION OF COAL IN COAL PREPARATION

BY LOUIS C. MC CABE

The petrographic investigations of coal of the past 2 decades have stimulated applied research in the field of preparation and utilization. Definition of the different types and varieties of coal was followed by the accumulation of a body of information on the specific physical characteristics.

Differences in specific gravity, conductivity, and friability have been utilized in commercial and laboratory preparation to separate coals into their component parts. The availability of quantities of the different types in concentrated form has made

large-scale combustion research possible. Laboratory tests for ignition temperature, agglutinating value, and swelling index are being perfected and, when correlated with coking, briquetting, and combustion practice will facilitate the solution of problems arising in these fields.

STATUS OF GLACIAL INVESTIGATIONS IN CANADA AND THE NEW GLACIAL MAP OF NORTH AMERICA

BY D. A. NICHOLS

Most of the knowledge of glacial geology in Canada has been gained from field observations by geologists studying essentially economic problems in limited areas, or by men doing broad exploratory work, the glacial observations being a by-product. Few detailed studies of the vast glaciated area have been made such as those accomplished by American geologists along the southern fringe of the glaciated region.

G. M. Dawson, Tyrrell, Low, and a few others have drawn inferences regarding the glacial centers about Hudson Bay and the Labrador Peninsula during rapid exploratory work. J. W. Dawson and Chalmers recorded an enormous amount of information about Eastern Canada, but their interpretations have left a confused idea of the succession of events. Coleman made detailed studies of interglacial beds at Toronto and from having traveled widely made many broad syntheses. W. A. Johnston has contributed the best information on glacial events in many parts. Goldthwait and Antevs have done considerable research in special regions. Paleontologists, agronomists, geographers, and many others have contributed to the mass of information, but the field is still wide open for glacial research in almost every part of Canada.

With the object of assembling all these data on one sheet, the new Glacial Map of North America has been undertaken. It is being compiled on a scale of 40 miles to 1 inch and will be published on a scale of 60 miles to 1 inch, if possible. It makes available a great deal of unpublished material and will include all recorded striae, drumlin, esker, and moraine patterns, proglacial lakes and rivers, and data regarding the highest marine strand lines. Facts, not interpretations, have been guides in compilation.

To date, the compilation has confirmed many suspected relations and indicated some unknown ones. It is anticipated that many research problems will be suggested. The map will also be invaluable for class-room purposes.

APPLICATIONS OF MODERN CLAY RESEARCHES IN CERAMICS

BY F. H. NORTON

Even though clay has been used for a great many thousand years, it was not until recently that we have been able to form a good picture of the nature of this material. It is shown in this paper that clay is a complex mixture made up of a number of hydrated alumina-silica minerals of comparatively fine grain size and generally platelike. In addition to the clay minerals there are various impurities present such as quartz, feldspar, mica, and in some cases organic matter such as lignite or humic acid. Many of the clays also contain soluble salts from the ground water which have a strong influence on their physical properties. Clay, having such a large surface, is very sensitive to adsorbed ions, and many of the variations found in clay may be traced back to changes in this adsorbed material. Research is described which has permitted the control of all these factors with considerable ac-

curacy and which relates them to the physical properties, particularly in connection with the plasticity of stiff clay-water mixtures and the viscosity of casting slips.

MODERN SURFACE METHODS IN THE GEOLOGICAL SEARCH FOR OIL

BY ED. W. OWEN

In addition to older methods of mapping surface structure, modern technique relies upon aerial photographic maps for much information as to the distribution and attitude of surface beds which are otherwise obscure. Aerial photographs have a wide field of usefulness in inaccessible or difficult terrane, in reconnaissance work, and in physiographic interpretation. Electrically logged shallow drill holes are employed in areas where workable exposures are absent and are also used to supplement surface information with accurate data as to the character and thickness of outcropping formations. The economic value of a comprehensive surface map depends upon the degree to which deep-seated structure can be inferred from it. Consequently, the results of analyses of well samples and of electrical surveys of drill holes are used as a basis for the interpretation of subsurface structure and geologic history in relation to the surface structure. The effectiveness of geophysical exploration depends largely on the extent to which it is integrated with surface and with other subsurface technique. Physiographic features are indicative of geological structure and play a significant role in preliminary exploration and in areas where direct surface structural evidence is not available. Careful correlation of the knowledge accumulated from surface and subsurface studies affords new concepts of the tectonic history of a large part of the earth and offers unlimited possibilities for a more thorough understanding of the relationship among diastrophic events, the destruction by erosion of the features resulting from them, and the consequent deposits. More energetic research into the vast store of information resulting from petroleum exploration would afford new fundamental knowledge of earth processes and geologic history.

GROUND WATER AND ITS ROLE IN PETROLEUM ACCUMULATION

BY F. B. PLUMMER

Petroleum occurs wherever the following factors prevail: (1) epicontinental marine sediments; (2) geosynclinal or broad monoclinal regional structure comprising sediments rich in finely divided plant remains interbedded, or in contact, with extensive aquifers. The water is fresh or brackish along the edge of the structure, and salty downdip, indicating that the movement of the original water and its saline and hydrocarbon content is downward.

Petroleum accumulates in the aquifers wherever: (1) they are overlain by more or less impervious layers; (2) they have been deformed, or wedge updip against an impervious mass, so that loci of relatively lower pressure are produced. The lower pressures may be brought about by relatively higher elevation, by release of gas pressure, or by dilatancy. (3) The lowered pressure in the aquifer causes the connate water generally saline to be displaced by hydrocarbons which remain in the traps. A continuous, extensive aquifer with loci of local low pressure is necessary for oil accumulation.

Recent extensive investigations of pore sizes, of the forces required to move liquid and gas hydrocarbons through them, of the variation in subsurface pressures, and of the forces due to interfacial tension indicate that crude oil droplets cannot move

through a porous sand from synclinal positions to anticlinal positions by gravity alone.

The conclusion is reached that hydrocarbons migrate largely as gas particles and partly as liquid films enveloping gas bubbles along with the slow downward movement of the ground water toward the lower part of the region, and that as the tiny gas bubbles come within the influence of decidedly low-pressures they accumulate in the trap.

INFLUENCE OF PHYSICAL CONSTITUTION OF COAL UPON ITS CHEMICAL, HYDROGENATION, AND CARBONIZATION PROPERTIES

BY GEORGE C. SPRUNK

Coal is a heterogeneous mass of several physically and chemically different classes of plant constituents that have accumulated in various proportions during the peat stage. Different blends of these constituents and the amount of biochemical changes in the peat stage result in the common types of coal known as bright coal, semi-splint, splint, cannel, and boghead.

This paper presents considerable information on the chemical and physical properties of the types of coal and also on the individual components such as spores, resins, and woody constituents which determine the coal types. Different types of coal from the same column sample of a bed often show wide variations in chemical and physical properties.

The yields of coke and of tar and light oil, as determined by low-temperature carbonization assays, have been found to be closely related to the chemical analyses of the different types of coal, and from the analyses the yields of these products can be predicted accurately.

Small-scale hydrogenation tests on constituents of coal indicate that bright coals are more suitable than splint coals for conversion into liquid products. The portions of coal that are translucent in thin sections under the microscope are readily hydrogenated and give high yields of liquid fuels; constituents like fusain and the ground mass of splint coals that are opaque under similar conditions are difficult to liquefy.

From the data obtained in the present work, it becomes increasingly evident that the type of coal as well as rank of coal must be given consideration whenever differences in coal properties are to be explained.

GLACIATION OF CANADA'S WESTERN ARCTIC

BY A. L. WASHBURN

Although the southern boundary of Pleistocene glaciation is comparatively well established, a survey of the literature discloses little evidence and highly divergent views regarding possible northern limits of North American glaciation, especially in Canada's Western Arctic. The problem is hampered by the fact that several of the commonly used evidences of glaciation in other regions, particularly erratics and deposits with the characteristics of till, are not dependable in this region because of marine ice rafting and solifluction. More reliable evidences are landforms of glacial origin and well-smoothed bedrock exposures showing striae parallel for long distances over a considerable area.

Field investigation in the region around Victoria Island proves that certainly most, and probably all, of Victoria Island, and the Royal Geographical Society Islands, were glaciated. It suggests glaciation of at least the southern portion of Banks Island. Glacial striae have been reported from Melville Island, and there seems to be no

geologic field evidence on record indicating lack of Pleistocene glaciation on other islands in this area. It appears that Pleistocene glaciation of Canada's Western Arctic was areally of considerable importance, but information concerning the complete areal extent must await further investigation. Striae in the Canadian Arctic are plotted, and directions of glaciation considered.

APPLICATIONS OF MODERN CLAY RESEARCHES IN CONSTRUCTION ENGINEERING

BY HANS F. WINTERKORN

One field in construction engineering is concerned with the settlement of buildings and the stability of dams, fills, and cuts, which are governed by mechanical properties such as compressibility, permeability, and resistance to shear. The soil masses considered are large and practically outside the zone of frequent moisture and temperature change. In this field, the impacts of modern clay researches have been mainly explanations for empirically found and mathematically formulated rules. Thus, Terzaghi used the plate shape of clay particles to explain the great compressibility of clay systems.

In highway engineering, the soils considered are within the zone of daily and seasonal moisture and temperature changes. Therefore, their properties must be known as functions of these variables. The constants of these functions are determined mainly by the crystal structure, the gross chemical composition, and the type and amount of exchangeable ions of the clay. These latter properties also influence the growth and shape of ice crystals in soils. The present theory on origin and prevention of frost boils has utilized only part of this concept.

Base exchange has been employed in construction to alter undesirable soil properties (Treasure Island, San Francisco). The ease with which a road bed is stabilized by means of bitumen or Portland cement depends upon the SiO_2-R_2O_3 ratio and on the type and amount of exchangeable ions of the clay fraction.

PAPERS PRESENTED AT PHILADELPHIA (1940) MEETING BUT NOT PREVIOUSLY PUBLISHED

MECHANICS OF A HYPOTHETICAL HAIL RING TO LOWER THE LEVEL OF THE OCEAN

BY A. H. FRETZ

The near approach of a sizable heavenly body to the earth could by tidal disruption raise spirally water from the ocean into a "hail ring" and so lower the level of the water.

While the ocean is lowered about 9000 feet, submarine canyons would be cut by running water. The weight of the water so lifted is of the order of 1¼ quintillion tons, and the unloading is unequally distributed over the surface of the earth.

The lifted water assumes the configuration of a chain link or a "hail ring". The "ring" can be nearly circumpolar instead of equatorial. Applying the inverse of Roche's Law, the limit of withdrawal is about 34,000 miles. By selecting suitable dimensions, outer radius 32,000 miles, inner radius 12,000 miles, and a width of 200 miles, the hail is distributed as a mist. It would seem then to satisfy the velocity of escape of each of the particles. The "ring" as a whole rotates around the earth in 8½ days. Outside forces would eventually destroy the equilibrium of each particle. The falling might well be the explanation of the ice of the Glacial period. Eventually, by fall and melt, the water is returned to the ocean, which regains its original level.

PETROLEUM UTILIZATION AND ITS EFFECT ON WAR INDUSTRIES

BY JOHN W. FREY

The position of petroleum is entirely different now from what it was in the period 1914-1918. The basic demand for petroleum products today is influenced by almost every desire, and the quantity consumed in normal civilian life is so large that, except for a few special products, the direct military operations probably will remain a small but increased fraction of the total.

The major function of petroleum is in distance-annihilation, most of which is by land travel, a product of automobiles, improved highways, and motor fuel. In the past 2 decades the pattern of land occupance and utilization has been revolutionized by automotive devices powered with petroleum-consuming engines. Metropolitan areas have changed from concentration at their centers to peripheral developments largely made possible through the greater flexibility in motor transport for labor and materials. Greater industrial diffusion is a recent trend. The use of tractors and trucks by farmers has not only changed the operation of farms but also the distribution of agricultural products. The by-product, fuel oil, has ceased to be an incidental product.

Totalitarian war involves petroleum not only as a source of power for fighting machines and military transport but also for maintaining normal civilian requirements as protection for the rear lines of supply and communication. Acceleration of production by war time industries is more significant as a factor in increased petroleum demand than the superimposed direct demand for military operations. Petroleum is one of the more important integrating factors in our economic life.

COMPLEX STRUCTURES OF THE NEW RIVER BASIN

BY A. A. L. MATHEWS

New River is an antecedent stream which has incised all of the shingle blocks between Blowing Rock, North Carolina, and Rich Creek, Virginia; thus, it has exposed the general and detailed structures of the basin. These structures consist of parallel series of the major thrust blocks, open and closed pitching folds, and a number of complex structures expressed in branch faults, telescope faults, clip-folds, westward-dipping fault plane, outliers, and the unusual structure where a deep-seated anticline is capped by a superficial syncline.

Since erosion has been extensive in the basin, and since only the stubs or roots of the Appalachian geanticline are left, each major structure has its associated topographic expression. The topography associated with the major thrust faults are fault-line scarps. One exception to the rule is noted in the St. Clair fault—*i.e.*, the northwest fault—where the topography is a modified fault scarp. Thus, there is a decrease in the depth of erosion across the shingle blocks from the southeast toward the northwest. This suggests that the St. Clair fault was the last major fault to develop in the basin.

In all major thrust fault blocks, the overriding block is composed of either old granites or thick-bedded dolomites. These are the competent members and serve as load carriers. In each instance the overridden block forms an overturned syncline adjacent to the fault plane. The complex structures are associated either with the major fault zone or in synclines on the mountain blocks.

CAMBRIAN-ORDOVICIAN BOUNDARY IN THE CHAMPLAIN VALLEY

BY ROBERT R. WHEELER

Recent field work revealed late Upper Cambrian (Hoyt) fossils in the upper part of Division B of the "Calciferous" formation. Previous investigators considered these beds Tribes Hill (Beekmantown) in age. The Tribes Hill and *Lecanospira* faunas were found above the cross-bedded base of Division C, however. Thus, the Hoyt fauna overlies the Little Falls dolomite in the Champlain and Mohawk valleys instead of underlying it as previously designated.

The Little Falls (and to the east the Hoyt) is separated in the Mohawk Valley from the Tribes Hill by an erosion interval due to offlap. At localities northeastward in the Champlain Valley dolomitic strata overlie the Hoyt and are separated from the Tribes Hill by near-shore cross-bedded sandstone indicating incomplete emergence. Still farther northeast the sandstone gives way to an off-shore facies (interbedded sandstone and shale) where sedimentation was least affected by emergence.

Since a recognized late Upper Cambrian fauna underlies the sandstone base of Division C, and an accepted Lower Ordovician fauna overlies it, the base of the Beekmantown must be moved up to the base of Division C. Likewise, the physical and faunal evidence advanced supports the placing of the Cambrian-Ordovician boundary at the base of Division C.

LATE CAMBRIAN SAUKIINAE IN THE CHAMPLAIN VALLEY

BY ROBERT R. WHEELER

Late Upper Cambrian fossils in lowermost "Beekmantown" strata in the Champlain Valley are closely related to those in the Hoyt fauna of Saratoga, New York. This indicates that the Hoyt (whose type section is structurally isolated) is much

higher stratigraphically than previously supposed. The trilobites are compared with those of the Conococheague of the Central Appalachians and of the Gorge of the Central Sequence of Vermont.

The Saukiinae are taxonomically as well as stratigraphically interesting. *"Dikellocephalus" hartii* (Walcott), certain other known species, and two new species from the Hoyt are assigned to a new genus.

Various features of these trilobites suggest derivation from tellerinids. The trend of these species toward more primitive characteristics may be prognostic of a post-*Tellerina* racial extinction.

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